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Newark Bay Study Area
Problem Formulation

Baseline Human Health and
Ecological Risk Assessment

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Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzofuran
AOC	Administrative Order on Consent
AE	assessment endpoint
AVS	acid volatile sulfides
BAZ	biologically active zone
BEHP	bis(2-ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
BHHERA	Baseline Human Health and Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
BSAF	biota-sediment accumulation factor
CARP	Contaminant Assessment and Reduction Project
CBR	critical body residue
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
cm	centimeter(s)
COPC	constituent of potential concern
COPEC	constituent of potential ecological concern
CPG	Cooperating Parties Group
CSM	conceptual site model
CSO	combined sewer overflow
DDT	dichlorodiphenyltrichloroethane
dioxin	polychlorinated dibenzo-*p*-dioxin (PCDD)
DO	dissolved oxygen
DRA	deterministic risk assessment
EFH	essential fish habitat

ERA	ecological risk assessment
ESC	ecological screening criteria
ft	foot/feet
ft/sec	feet per second
furan	polychlorinated dibenzofuran (PCDF)
g/day	gram per day
GSI	gonado-somatic index
HDP	Harbor Deepening Project
HHRA	Human Health Risk Assessment
HMW	high-molecular-weight
HQ	hazard quotient
IPCS	International Program on Chemical Safety
LMS	Lawler, Matusky and Skelly Engineers, Inc.
LMW	low-molecular-weight
LPRRP	Lower Passaic River Restoration Project
m	meter(s)
m/sec	meters per second
ME	measurement endpoint
MLW	mean low water
NBSA	Newark Bay Study Area
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NY/NJ	New York/New Jersey
NYSDEC	New York State Department of Environmental Conservation
OEHHA	Office of Environmental Health Hazard Agency
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response

PAH	polycyclic aromatic hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PAR	Pathways Analysis Report
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin (dioxin)
PCDF	polychlorinated dibenzofuran (furan)
PCN	polychlorinated naphthalene
ppth	parts per thousand
PRA	probabilistic risk assessment
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RARC	Risk Assessment and Risk Characterization
redox	reduction-oxidation potential
REMAP	Regional Environmental Monitoring and Assessment Program
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIWP	Remedial Investigation Work Plan
SAP	Sampling and Analysis Plan
SEM	simultaneously extracted metals
SI	Sediment Investigation
SLERA	Screening-Level Ecological Risk Assessment
SQT	sediment quality triad
SVOC	semivolatile organic compound
SWO	stormwater outfall
TEF	toxic equivalency factor
Tierra	Tierra Solutions, Inc.
TOC	total organic carbon
TRV	toxicity reference value

USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WHO	World Health Organization
Windward	Windward Environmental, LLC

1. Introduction

Pursuant to the Statement of Work appended to the Administrative Order on Consent (AOC) for the Remedial Investigation and Feasibility Study (RI/FS), Newark Bay Study Area (NBSA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Index No. 02-2004-2010 (U.S. Environmental Protection Agency [USEPA] 2004), one of the goals of the RI/FS is to “Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals contaminated sediments in the NBSA” (USEPA 2004). To accomplish this goal, baseline human health and ecological risk assessments will be conducted in the NBSA, which is identified as Newark Bay (the Bay) and portions of the Hackensack River, Kill van Kull, and Arthur Kill (USEPA 2004). A regional map showing the NBSA is provided as Figure 1-1.

As part of the risk assessment process, this Problem Formulation was prepared by Tierra Solutions, Inc. (Tierra) on behalf of Occidental Chemical Corporation (the successor to Diamond Shamrock Chemicals Company [formerly known as Diamond Alkali Company]) to establish the overall goals, breadth, and focus of the baseline ecological and human health risk assessments. This report documents issues that need to be addressed in the risk assessments, which are based on the potentially complete exposure pathways and effects, identified as part of the conceptual site model (CSM) (refer to *Interim Conceptual Site Model*, Tierra 2011).

This Problem Formulation was prepared according to guidance from the following sources:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. EPA/540/R-97/OCS. (USEPA 1997)

- *Considerations for Developing Problem Formulations for Ecological Risk Assessments Conducted at Contaminated Sites under CERCLA: A Discussion Paper*. Prepared for M. Greenberg, Environmental Response Team, USEPA (MacDonald Environmental Sciences Ltd. and Cantox Environmental, Inc. 2004)

1.1 Summary of Risk Assessment Guidance

1.1.1 Ecological Risk Assessment

The USEPA eight-step Superfund ecological risk assessment process (ERA) (USEPA 1997) is shown on Figure 1-2. Step 1 (Screening-Level Problem Formulation and Ecological Effects Evaluation) and Step 2 (Screening-Level Exposure Estimate and Risk Calculation) were completed in the *Newark Bay Study Area Pathways Analysis Report* (PAR) (USEPA 2006b) and *Screening-Level Ecological Risk Assessment* (SLERA) *for the Newark Bay Study Area* (USEPA 2008a), respectively. Although the results of the SLERA are highly conservative and many of the conclusions regarding potential chemical risks are highly uncertain, the results of the SLERA clearly indicate that a Baseline Ecological Risk Assessment (BERA), encompassing Steps 3 through 8, is required for the NBSA. In addition, the SLERA contains a compilation of substantial ecological data and information to help guide the BERA process.

The ecological risk sections of this document represent Step 3 (Problem Formulation) of the eight-step ERA process. Specific objectives of Step 3 per USEPA (1997) are:

- Refine preliminary constituents of potential ecological concern (COPECs)
- Further characterize ecological effects of COPECs
- Review and refine information on COPEC fate and transport, complete exposure pathways, and ecosystems potentially at risk
- Select assessment endpoints (AEs)
- Develop a CSM with working hypotheses or questions that the site investigation will address

Steps 4 and 5 of the ERA process, which encompass the overall study design and field sampling, are anticipated to be driven by the information contained within this document. Finally, results from Step 6 (Analysis) and Step 7 (Ecological Characterization) will be presented in the BERA report. Results of the BERA will be used to manage ecological risks in the NBSA by informing the remedial action decision-making process (Step 8).

1.1.2 Human Health Risk Assessment

A Baseline Human Health Risk Assessment (BHHRA) will be conducted for the NBSA following USEPA's Risk Assessment Guidance for Superfund (RAGS) Human Health Evaluation Manual (USEPA 1989, 2001a). Other documents that will be used include, but are not limited to, Guidelines for Carcinogen Risk Assessment (USEPA 2005a), Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA 2005b), and Recommended Toxicity Equivalence Factors for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin and Dioxin-Like Compounds (USEPA 2010c).

The BHHRA will be conducted following a two-tiered approach designed to support risk management decision-making by initially defining the constituents of potential concern (COPCs) for each medium, based on existing and new data collected during the Remedial Investigation (RI), and using this information to prioritize areas requiring further assessment. The Interim CSM (Tierra 2011) will be updated, as appropriate, and COPCs will be identified using the approach previously approved by USEPA for the Lower Passaic River Restoration Project (LPRRP) (Windward 2012). Once the CSM is reviewed and approved by USEPA, RAGS Part D Tables 1 through 6 will be prepared for review and approval. Following approval, risk assessment calculations will be conducted in a deterministic risk assessment (DRA). Depending on the results of the DRA, a probabilistic risk assessment (PRA), consistent with RAGS Volume III Part A Process for Conducting Probabilistic Risk Assessment (USEPA 2001b), may be proposed for refining human health risk and hazard estimates in the NBSA. The PRA may also be used to determine risk-based remediation goals. Use of PRA techniques will follow USEPA guidelines (USEPA 2001b) and will be conducted with USEPA oversight of all input parameter distributions and modeling approaches. The goal of the PRA is to provide more information regarding the range and distribution of risks associated with site contaminants to inform remedial decisions.

1.2 Report Organization

This Problem Formulation is organized into the following sections:

- Section 2: Environmental History and Setting of the NBSA – Provides a concise summary of the site in terms of historical, industrial, and physical setting.

- Section 3: Data Summary – Provides a description of the available qualitative and quantitative data that are currently available for the risk assessments.

- Section 4: Baseline Ecological Risk Assessment – Presents the ecological CSM, including receptors and exposure pathways; discusses assessment and candidate measurement endpoints (MEs) and data needs for the BERA.

- Section 5: Baseline Human Health Risk Assessment – Presents the human health CSM, including receptors and exposure pathways, and data needs for the BHHRA.

- Section 6: Next Steps – Outlines future steps in the risk assessment process that will be conducted following approval of the Problem Formulation.

- Section 7: References – Provides a list of cited literature.

2. Environmental History and Setting of the NBSA

Newark Bay is situated between the cities of Newark and Elizabeth and is bordered by Newark Liberty International Airport to the west, Jersey City and Bayonne to the east, and Staten Island, New York to the south (Figure 2-1). The Passaic and Hackensack Rivers empty into Newark Bay in the north. Two tidal straits in the southern portion of the NBSA, Kill van Kull and Arthur Kill, connect the Bay to Upper New York Harbor and Raritan Bay, respectively. Other tributaries with their confluences in the NBSA include the Elizabeth River, Peripheral Ditch, and Piersons Creek.

2.1 History

As part of the New York/New Jersey (NY/NJ) Harbor Estuary, Newark Bay has evolved into a key shipping port and ideal setting for myriad industries for over two centuries (Brydon 1974; Cunningham 1954, 1966a, 1966b; Meyers 1945). The NBSA is home to major cargo ports, an international airport, numerous industrial properties, and has several bridge crossings for automobile and rail travel between New Jersey and New York. The history of the NBSA is a key factor in understanding the current conditions of the site. As population, industry, and commerce grew during the 1800s and 1900s, significant expansion and development of the NBSA occurred. An historical timeline of major development activities in the NBSA is presented on Figure 2-2.

Situated at the center of one of the most urbanized and industrialized areas in the United States, the NBSA has been subjected to environmental degradation over the past two centuries due to a variety of factors: shoreline and land development (U.S. Army Corps of Engineers [USACE] 2006b), wetlands destruction, habitat degradation, garbage and sewage disposal, and releases of hazardous substances (Iannuzzi et al. 2002). As a result of such practices, the NBSA is known to contain a number of chemical constituents, including but not limited to, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides, herbicides, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated dibenzo-*p*-dioxins (PCDDs, or dioxins), polychlorinated dibenzofurans (PCDFs, or furans), and metals (National Oceanic and Atmospheric Administration [NOAA] 1995; USEPA 1998). These constituents originate from a variety of sources throughout the Newark Bay area (Bonnevie et al. 1994; Crawford et al. 1994, 1995; Gillis et al. 1993, 1995; Gunster et al. 1993a, 1993b; Huntley et al. 1995; Iannuzzi et al. 1995). Industries such as metal refineries, dye manufacturers, tanneries, lumber processors, petroleum processors, chemical manufacturers, and ship builders have produced products using hazardous chemicals that have been discharged into Newark Bay or its tributaries (Iannuzzi et al. 2002). Additionally, garbage, sewage, and contaminants have also been released into the waters of the NBSA, adjoining tributaries, and tidal straits through dumping, storm sewers, and combined sewer overflows (CSOs) (Crawford et al. 1994; Gunster et al. 1993b). Extensive shipping traffic in Newark Bay, as well as pipeline and facility operations, have resulted in numerous oil and chemical spills, also leading to contamination of NBSA sediments.

In addition to contamination of the NBSA, development of the shoreline has led to the destruction of wetlands and a sharp decline in habitats for plants and animals (Iannuzzi et al. 2002). Between 1891 and 1934, a series of navigation channels were constructed by the federal government. In addition, a marine terminal at Port Newark was constructed by the City of Newark and Newark Liberty International Airport opened in 1927. In 1948, the Port Authority of New York and New Jersey (PANYNJ) assumed management of the airport, and the shoreline was filled for expansion activities beginning in the late 1940s through 1970 (PANYNJ 2012a). Development of the Newark Liberty International Airport led to the construction of the Peripheral Ditch, which receives and transports stormwater runoff into the NBSA. Construction of the Port Elizabeth Marine Terminal began in 1958, which also significantly changed the shoreline (PANYNJ 2012a).

Dredging was first initiated in the Newark Bay area in 1874 to accommodate deep-draft vessels (USACE 2007b). Large quantities of dredged material removed during Newark Bay development activities were used as fill for large stretches of Newark Bay's shoreline to facilitate industrial, residential, and recreational development. Over time, several major metropolitan areas were built along the shores. With increases in technological advancements, industry, and trading, the need for transportation into and around Newark Bay grew. In-filling portions of Newark Bay for new construction was not only a necessary practice, but became commonplace. In addition to the growth of port and vessel traffic, various bridges were also built for interstate automobile and train traffic.

2.2 Physical Setting

Tributaries to the NBSA are shown on Figures 1-1 and 2-1. Newark Bay is hydrodynamically influenced by three major forces: tributary flows from the Passaic and Hackensack Rivers and the Kills, astronomical tides, as well as local and regional meteorological events (Herrington et al. 2002; Wakeman 2006). Each of these forces is described in more detail in this section. In addition, Newark Bay's geographic and geomorphic areas are described in Sections 2.2.1 and 2.2.2, respectively.

2.2.1 Geographic Areas

The NBSA has been subdivided by geographic area, as presented on Figure 2-3. The major geographic areas, from north to south, are:

- Passaic River
- Hackensack River
- Newark Bay North
- Newark Bay Central
- Port Channels
- Newark Bay South
- Kill van Kull
- Arthur Kill

The baseline risk assessments will focus on the three major geographic areas that form Newark Bay proper – Newark Bay North, Central, and South – which is consistent with the analyses conducted for the SLERA (USEPA 2008a). In addition, a full site-wide evaluation that incorporates all geographic areas will also be conducted, commensurate with the SLERA.

As discussed above, the Passaic River is being addressed under a separate AOC that includes investigation and cleanup of the lower 17 miles of the river. Contaminated sites along the Hackensack River and the Kills are also being addressed under separate programs. Although portions of Kill van Kull and Arthur Kill are located in the NBSA, the entirety of these tidal straights will not be included for evaluation in the baseline risk assessments.

2.2.2 Geomorphic Areas

The NBSA has been grouped into seven distinct geomorphic areas based on comparable bathymetry and slopes, hydrodynamic conditions, and historical influences (Figure 2-4). The boundaries/shapes of these areas have evolved with the development of information presented in prior reports (Tierra 2005, 2007, 2011):

- Historically Disturbed Subtidal Flats
- Industrial Waterfront Area
- Intertidal Areas
- Navigation Channels
- Port Channels
- Subtidal Flats
- Transitional Slopes

The Newark Bay Confined Disposal Facility (CDF) is another notable area that comprises less than 1% of the NBSA, but is not considered a geomorphic area due to the use of this area for waste disposal. It was constructed in 1997 within a subtidal flat in the central portion of Newark Bay, between the Port Newark and Elizabeth Channels (Douglas et al. Undated). The CDF reached capacity in 2011 and was closed and capped with at least 3 feet of sand in June 2012 (Newark Bay Study Area Coordination Team 2012). As a result, the CDF will be excluded from analysis in the baseline risk assessments.

Five of the seven geomorphic areas have unique ecological characteristics and provide important habitat, as discussed below.

2.2.2.1 *Subtidal Flats*

The broad, shallow Subtidal Flats located outside of the navigation channels cover approximately 43% of the NBSA (Figure 2-4). Water depth in the Subtidal Flats averages approximately 9 feet (ft) based on the bathymetric survey conducted as part of the Phase I Sediment Investigation (Tierra 2005, 2007). Water flow in these areas is largely driven by tidal influence and local winds.

The Historically Disturbed Subtidal Flat geomorphic area was defined for sediment characterization and nature and extent investigational purposes. These are specific areas located within the Subtidal Flats that were altered by anthropogenic activities, such as dredging or construction. Intermittent natural sedimentation and lack of maintenance has since filled the former depressions to a sediment bed elevation that is comparable with the surrounding Subtidal Flats. The surficial features and habitats of the Historically Disturbed Subtidal Flats are similar to the surrounding Subtidal Flats; only the subsurface sediment characterization differs. Because the risk assessments focus on surficial sediments, the term Subtidal Flats will be used to represent both the Subtidal Flats and the Historically Disturbed Subtidal Flats.

USACE catch data indicate the fish community in the Subtidal Flats is dominated by small schooling fish (e.g., bay anchovy [33%] and Atlantic herring [29%]), with fewer larger fish (e.g., white perch [14%] and striped bass [8%]) (USACE 2009).

2.2.2.2 *Transitional Slopes*

Transitional Slopes (Figure 2-4) are located between the deeper dredged channels and the Subtidal Flats. This geomorphic feature covers approximately 10% of the NBSA, with average water depths of approximately 25 ft. The slopes are generally 3 to 1 based on observations from available NOAA bathymetric charts and consistent with the results of the bathymetric survey conducted as part of the Phase I Sediment Investigation (Tierra 2005).

The shallow portions of the Transitional Slopes would be expected to exhibit habitat similar to that of the Subtidal Flats. The deeper portions of the transitional slopes likely lack any vegetation or habitat importance due to periodic maintenance dredging, deepening-project activities, and limited sunlight conditions at depth.

2.2.2.3 *Channels*

Navigation Channels (Figure 2-4) include the main federal channels within Newark Bay and cover approximately 25% of the NBSA. Other privately dredged channels lead from the navigation channels to various waterfront facilities, particularly along the industrial waterfront on Staten Island and along Bergen Point on the southeast side of Newark Bay. Navigation Channels south of Port Newark, with the exception of the channel south of Shooters Island, have, since 2001, been dredged to maintain water depths of 35 to 50 ft below mean low water (MLW). These areas are also currently part of the Harbor Deepening Project (HDP), which is deepening these channels to 50 ft below MLW North of Port Newark to the mouths of the Passaic and Hackensack Rivers; the federal Navigation Channel was last dredged in 1989, at which time the project depth was 35 ft MLW. Additional information regarding maintenance dredging practices in the NBSA is provided by USACE (2007b).

The Navigation Channels are unique from the rest of Newark Bay due to the deeper depths that are maintained by dredging for vessel traffic that utilizes these areas.

Based on a bathymetric survey conducted in 2005, the average depth of the Navigation Channels is approximately 45 ft (Tierra 2005). Since this survey, however, some areas of the southern channels have been deepened to approximately 50 ft as part of the HDP. Due to their deep depths, the Navigation Channels are not subject to wind-wave resuspension and have a tendency to accumulate sediments (Tierra 2005). However, preferential sediment deposition within the Navigation Channels occurs along the sides of the channels where sediments are least subject to navigation-induced resuspension (Wakeman 2006).

Port Channels are located at Port Newark, Elizabeth, and South Elizabeth. Within these ports, large marine vessels maneuver and dock for cargo exchanges, then exit from the piers. The types of forces generated by vessels in these areas create a unique hydrodynamic condition. The Port Channels account for approximately 6.2% of the NBSA, with average water depths of approximately 48 ft (Tierra 2005). Maintenance dredging occurs on a regular basis within the established Port Channels and associated berths for container ships at the larger terminals. Berths associated with privately owned properties along the shoreline of the NBSA are also periodically maintained.

There is little to no difference in the ecology or the biological communities of the Port Channels verses the Navigation Channels. As such, the term Channels will be used to encompass both the Port and Navigation Channels as a whole in the baseline risk assessments. Biological communities in the deep Channels of the NBSA include benthic invertebrates and predatory fish. Surveys have shown blue crabs and predatory fish (e.g., striped bass) to be abundant in the deeper water of the Channels in the winter months (USACE 1997). USACE community trawl data collected between 2002 and 2009 were separated based on Channel catch vs. non-Channel catch. Overall, 42% more organisms were captured in the Channels than in the non-channel areas; large fish species, such as white perch, striped bass, and spotted hake, dominated the catch in the Channels (USACE 2009).

2.2.2.4 *Intertidal Areas*

Intertidal Areas (Figure 2-4) are characterized by two main features: wetlands and mudflats (or sand/cobble flats) that are typically exposed during low tide. Figure 2-5 shows the NBSA wetland areas, which are typically characterized by the presence of emergent vegetation, such as common reeds (*Phragmites australis*) and/or saltmarsh cordgrass (*Spartina alterniflora*), as well as soft muddy or organic substrates. Wetlands may provide important foraging and nesting grounds for seasonally abundant waterfowl and other water birds. Mudflats, sand, and cobble flats are characterized by unvegetated expanses of mud, fine sand, or clay. Benthic organisms, such as infaunal invertebrates, crustaceans, bivalves, and forage fish, can be found in these areas. They are also important feeding areas for predatory fish and shorebirds, such as herons, egrets, and sandpipers.

Most of the wetlands historically present around the fringes of the NBSA have been filled, yet small Intertidal Areas remain in various locations around Newark Bay – these represent less than 1% of the area within the NBSA.

2.2.2.5 *Industrial Waterfront Area*

As previously described, the Newark Bay shoreline has been significantly modified by human activities over time. These modifications include construction of marine facilities, privately dredged channels, publicly owned treatment works, CSOs, stormwater outfalls (SWOs), rip-rap, and other facilities. The large number of constructed pier and shipping facilities along the waterfront is evidence of extensive historical removal, reworking, and disturbance of sediments. These facilities also present numerous physical obstructions to water currents and may cause highly localized variation in sedimentation patterns.

For purposes of the RI, shoreline areas along the NBSA within 100 ft of the entire shoreline of the NBSA, excluding Intertidal Areas, are considered part of the Industrial Waterfront Area (Figure 2-4). This area covers approximately 8% of the NBSA with average water depths of 17 ft, not including upland areas.

Aquatic and wetland habitat is limited within the Industrial Waterfront Area. Though dilapidated pier structures and submerged wrecks, notably along the southern portion of Newark Bay, Kill van Kull, and Arthur Kill, may provide limited structural habitat for some juvenile and other small pelagic fish species, overall species abundance and diversity is reduced in these areas (Duffy-Anderson et al. 2003).

2.2.3 Tributaries

Major freshwater inputs to the NBSA are from the Passaic and Hackensack Rivers. The combined watershed for these two tributaries is approximately 726,700 acres in New Jersey and New York (USEPA 2012). The Passaic River is roughly 80 miles long with its origin in the center of Mendham, in southern Morris County, New Jersey. It meanders through the swamp lowlands between the ridge hills of rural and suburban northern New Jersey, called the Great Swamp. In the upper reaches of the Passaic River, its tributaries drain much of the northern portion of the state. Upriver of the

Dundee Dam in Little Falls, the mean daily flow is approximately 1,200 cubic feet per second (cfs; U.S. Geological Survey [USGS] 2012). In its lower reaches, the Passaic River flows through the most urbanized and industrialized areas of the state, including downtown Newark, and then it enters the upper northwestern corner of Newark Bay. Due to the severe pollution and industrialization in these parts of the river, the lower 17 miles of the Passaic River are identified as the LPRRP, with a separate AOC under the auspices of the CERCLA program.

The Hackensack River originates in Rockland County, New York, just west of the Hudson River and flows for approximately 50 miles into Newark Bay's upper northeast portion. Tributaries of the Hackensack include Sawmill Creek, Berrys Creek, and Overpeck Creek. Just south of the Oradell Dam in New Milford, New Jersey, the Hackensack River has a mean daily flow of approximately 90 cfs. To the south of this dam, an approximately 34 square-mile area known as the Hackensack Meadowlands consist of roughly 8,400 acres of wetlands that provide habitat to migratory birds, serve as a spawning area for fish, filter surface water runoff, and protect the uplands from storm surges. Historically, these barren areas were once considered wastelands and, as a result, were subjected to pollution, alteration, in-filling, and illegal dumping.

The Elizabeth River originates in Hillside, New Jersey, and is approximately 6 miles long. It drains a small, highly urbanized basin and flows into the Arthur Kill. This river has small discharges, typically less than 100 cfs, which are affected by inputs from sewers and other outfalls, several small dams, and wetland areas, all of which affect the hydrologic response (USGS 2010).

Piersons Creek, Peripheral Ditch, and Plum Creek are three small tributaries that flow into central Newark Bay. There are limited data for these tributaries. Piersons Creek and Plum Creek are associated with the area north and east of the Newark Liberty International Airport and are located in a highly industrialized area. The Peripheral Ditch is approximately 4 miles long and varies in width from 100 to 200 ft. It serves as the drainage trench for the airport, commencing along the west side of the facility, wrapping around the southern perimeter, and flowing into the NBSA on the east side of the airport.

The tidally influenced straits of the Kill van Kull and Arthur Kill serve as the main connectors between the NBSA and the Upper Bay of New York Harbor and Raritan Bay, respectively. The Kill van Kull is approximately 3 miles in length and 1,000 ft wide. The Arthur Kill is approximately 10 miles long and 600 ft wide. Both are maintained by regular dredging to accommodate cargo vessels travelling to ports and/or various private facilities along the NBSA and Arthur Kill.

Two small tributaries in Staten Island, New Creek, and Old Place Creek flow into the southern NBSA. These small tributaries also have extremely limited data. They are responsible for draining the northwest portion of Staten Island. New Creek is located along the eastern side of the Howland Hook Marine Terminal and is likely associated with the drainage of this facility. It originates just south of General Douglas MacArthur Park and is approximately 1 mile long. Old Place Creek is larger than New Creek and drains the marsh area south of Interstate 278, flowing into the NBSA just north of Goethals Bridge. It originates in the Graniteville Swamp Woods and is just over 1 mile long.

2.2.4 Tides

Newark Bay has a semi-diurnal tide with a tidal period of 12.42 hours (Chant 2006; Pence 2004). The tidal amplitude is similar throughout Newark Bay, with only slight variations in mean tide levels between the north and south ends of Newark Bay, with the mean tide level at the northern end (Kearny Point) equal to 2.85 ft (0.87 meters [m]) and equal to 2.77 ft (0.84 m) in the southwestern portion of Newark Bay (Pence 2004; Wakeman 2006). Although the tidal amplitude is similar throughout Newark Bay, tidal current velocities vary by location (Pence 2004). According to published tidal charts (NOAA 1998), the maximum ebb tidal current velocity is 2.7 ft per second (ft/sec; 0.8 m per second [m/sec]) towards the southwest near the Elizabeth Channel, and the maximum flood tidal current velocity is 3.0 ft/sec (0.9 m/sec) toward the northeast near the mouth of the Hackensack River. The weakest tidal currents are found south of the South Elizabeth Channel (west side) and in the cove south of Droyers Point (east side) (USACE 1997).

2.2.5 Storm Events

Due to its location along the northeastern coastline of the United States, the NBSA is vulnerable to hurricanes, tropical storms, blizzards, Nor’easters, and other strong storms. Major flooding events have occurred in the region resulting from the combination of significant storm events, as well as the tidal dynamics. Limited information is available on specific events that have caused flooding in Newark Bay; however, there is some information on flooding events caused by storms in the Passaic River. USACE (2006b, 2012a) and NOAA (2011) report a history of significant events that caused “major” flood conditions in the Passaic River, some as recently as 2012. NOAA (2011) also indicates that many of the flooding events (categorized as “minor,” “moderate,” or “major”) along the Passaic River are associated with channelization and regulation/diversion conditions in the river. This implies that not all major floods along the Passaic River resulted in flooding conditions in Newark Bay.

Figure 2-2 highlights periods of time when large, flooding storms occurred in the region, including major floods along the Passaic River. It should be noted that these conditions indicate potential flooding in the NBSA, but are not definitive as to whether flooding occurred in the NBSA.

3. Data Summary

To gain a thorough understanding of the ecosystem and current environmental conditions in Newark Bay, various historical and current literature and data/information sources were reviewed. These sources included, but were not limited to, regulatory agency-sponsored reports (e.g., the PAR [USEPA 2006b] and the SLERA [USEPA 2008a]), documents written by Windward Environmental, LLC (Windward 2011) and Windward/AECOM (2009) on behalf of the Cooperating Parties Group (CPG) for the LPRRP, and Tierra-sponsored reports, including studies summarized in the Inventory and Overview Report of Historical Data (herein referred to as the Inventory Report) in Volume 1 of the NBSA Phase I Remedial Investigation Work Plan (RIWP) (Tierra 2004).

The available data are divided into qualitative and quantitative data. Qualitative data provide an understanding of the physiography and land use, available ecological habitats and species present, as well as the recreational areas along Newark Bay. Quantitative data provide specific concentrations of constituents in biotic and abiotic media and will be used to calculate potential risks in the baseline risk assessments. Each type of data is described below. A full reference list is provided in Section 7.

3.1 Qualitative Data

Iannuzzi et al. (2002) and Crawford et al. (1994) present summaries of the environmental history of Newark Bay and the surrounding lands. Iannuzzi et al. (2002) review the historical ecology of the Passaic River and part of the Newark Bay estuary, showing how anthropogenic activities from the past 150 years have progressively degraded the natural ecology of the region. Crawford et al. (1994) demonstrate how both the abundance and diversity of aquatic species in the Newark Bay estuary have been substantially reduced since the late 1800s due to the intense industrialization and urbanization that occurred throughout the region. This section discusses the land use of the NBSA and describes the various ecological and biological communities that reside within each habitat in Newark Bay.

3.1.1 Land Use and Important Ecological Habitats

As depicted on Figure 3-1, which is based on the Anderson et al. (1976) land-use classification scheme, major land uses in the NBSA are barren land, forest, water, wetlands, and urban. Barren land occupies just over 1%; wetlands and forests each comprise around 2% of the land use in the NBSA. Water encompasses 22%, and the majority of land use (73%) in the NBSA today is classified as urban.

Despite the changing habitat conditions and urbanization of the NBSA during the 20th century, Newark Bay continues to serve as a spawning ground, migratory pathway, and a nursery/foraging area for a variety of aquatic organisms. The following sections describe each land-use category and the predominant organisms residing within these habitats.

3.1.1.1 *Water*

Water depth in Newark Bay ranges from approximately 9 ft in the shallow Subtidal Flats (Tierra 2007) to up to around 50 ft in the dredged channels (USACE 2012b). Salinity in Newark Bay ranges from approximately 14 to 24 parts per thousand (ppth), with an average annual salinity of approximately 20 ppth (USACE 2004b). The temperature of Newark Bay is typical of mid-Atlantic waters, ranging from near freezing during the winter months to around 25 degrees Celsius in the summer months. The variable conditions of Newark Bay support a wide range of species that inhabit several of the geomorphic regions: Subtidal Flats, navigation and port channels, and transitional slopes. Newark Bay provides habitat for invertebrates and fish freely swimming within the water column, as well as those residing on or within the benthos, as discussed in this section.

Aquatic Invertebrates

The zooplankton community can be divided into two major categories: permanent holoplankton (which include various forms of small, sometimes microscopic organisms, such as protozoans and copepods) and temporary meroplankton (which include larval stages of shallow-water invertebrates and fish). Among the meroplankton are the ichthyoplankton, consisting of egg, larval, and juvenile stages of fish. A major ichthyoplankton survey conducted in Newark Bay between 1993 and 1994 by the National Marine Fisheries Service (NMFS) collected larvae of 20 different species of fish. Only two species, bay anchovy (*Anchoa mitichilli*) and one unidentified goby (*Gobiosoma* sp.), were collected in substantial numbers at any time during the study year. Both species were present from June through September. The occurrence of these species in substantial numbers over several months indicates spawning in Newark Bay, whereas the low numbers and infrequent occurrence of the larvae of other species suggest they were spawned elsewhere and carried by tidal currents into Newark Bay (USACE 1997).

Ichthyoplankton were also collected by USACE from seven stations within Newark Bay during sampling events for the HDP (USACE 2011). Data collected between 1999 and 2006 (USACE 2003, 2004a, 2005, 2006a) are presented in Table 3-1. Forty-two species of ichthyoplankton were identified at various life stages (i.e., egg, larvae, or juvenile), including eggs and larvae from one unidentified species. It is unclear why the counts of juveniles are much lower than the other life stages for most species, but could be due to factors such as seasonality, method of capture, or identification procedures. Bay anchovy dominated the catch across all 8 years. All life stages were captured for bay anchovy, winter flounder (*Pleuronectes americanus*), weakfish (*Cynoscion regalls*), and windowpane flounder (*Scophthalmus aquosus*), indicating that these species are spawning and have early life stages in Newark Bay.

Benthic Invertebrates

Fourteen studies have been conducted on the benthic invertebrate communities of Newark Bay and its tributaries; six of which focused solely on Newark Bay (Tierra 2004). These studies consistently indicate that the benthic invertebrate communities throughout Newark Bay are characterized by low abundance and diversity, and that the benthic environment is stressed from various pollutants and anoxic conditions. Species lists in all existing studies are dominated by polychaete worms, oligochaete worms, and small bivalves (clams/mussels). These organisms serve as a forage base for a variety of crustaceans, fish, and wading birds.

A survey of benthic habitats in the NY/NJ Harbor Estuary conducted in June and October 1995 (Iocco et al. 2000) indicates that Newark Bay bottom sediments are predominantly characterized as silt with occasional sand. Grab samples from approximately one-half the stations contained benthic infauna, consisting of predominantly polychaetes (e.g., *Streblospio benedicti*) and bivalves (e.g., *Mulinia lateralis* and *Mya arenaria*). Benthic habitats, such as large clam beds and mats of *Ampelisca abdita* that were seen elsewhere in the NY/NJ Harbor Estuary, were not observed in Newark Bay. At several stations in Newark Bay, the sediment gas content indicated high pollutant or organic content. Feeding and anoxic voids were abundant in June.

In 1993-1994 and 1998-1999, USEPA (under the Regional Environmental Monitoring and Assessment Program [REMAP] program) collected 56 randomly located benthic invertebrate samples in the area referred to as the Newark Bay sub-basin, which, in addition to Newark Bay, included stations in the Arthur Kill, Lower Passaic River, and Hackensack River (USEPA 2003a). The study concluded that the overall benthic invertebrate community is characterized by low abundance and diversity and is dominated by pollution-indicative species. The Benthic Index of Biotic Integrity, an index calculated based on various structure and abundance metrics, indicated that as much as 90% of the Newark Bay benthos can be classified as moderately to highly impacted (Figure 3-2). All but one station within the NBSA boundaries was considered highly impacted (USEPA 2003a).

Surveys conducted by NOAA in 1993-1994 and USACE in 1995-1996 also found Newark Bay to be dominated by polychaetes and small clams, with a low diversity and abundance of pollution-indicative species (NOAA 1994; USACE 1997). Benthic infaunal abundance and species composition increase in the late winter and early spring months and decline in the summer (USACE 1997). The most abundant species observed in six benthic invertebrate surveys are identified in Table 3-2.

Communities of large invertebrates in the channels and shoals are mainly dominated by blue crabs (*Callinectes sapidus*), which are present year-round in Newark Bay. Blue crabs at shallow water stations (Subtidal Flats) appear to be more abundant in the summer and fall (May to November) and are nearly absent during the other months when they migrate to the deeper channels or offshore (USACE 1997). Bivalve mollusks in Newark Bay were dominated by the dwarf surfclam (*M. lateralis*) and the softshell clam (*M. arenaria*).

Various physical parameters can affect chemical constituents in sediments in the NBSA, making them more or less bioavailable to benthic invertebrates and other organisms. Such factors include, but are not limited to, total organic carbon (TOC), pH, sulfide content, reduction-oxidation potential (redox), and grain size. In addition, various hydrodynamic transport factors, both spatially and temporally, can also influence bioavailability. These include processes such as sedimentation, scouring events, resuspension, and deposition of suspended solids.

A study conducted in October 2005 at 14 stations in Newark Bay utilized sediment profile imagery and supplemental grab samples to determine the biologically active zone (BAZ) (Tierra 2008a). Results of the study indicate that the surface sediment is structured by physical (e.g., currents and sediment movement) and biological processes (e.g., movement of infaunal organisms), both of which can affect the bioavailability of chemical constituents. The fauna and biogenic structures observed were sufficient to bioturbate sediment to the estimated total BAZ depths of 13.7 to 16.4 centimeters (cm; average of approximately 6 inches or 0.5 ft). The deepest vertically burrowing species observed were large individuals of *Macoma balthica* and *M.*

arenaria clams. The species with the potential to create the deepest convoluted burrow galleries were *Glycera* spp. and *Nereis* spp. Other species found in the grab samples were the burrowing isopod *Cyathura polita* and large-bodied, tube-building polychaetes (*Diopatra cuprea*), maldanids (*Pectinaria gouldii*), and the amphipod *Ampelisca* spp. Most of the stations sampled in this investigation were composed of benthic assemblages in a Stage III (relatively well-developed) successional stage that suggests stability in the sediment structure (Tierra 2008a).

Fish

The finfish assemblage that resides in or is transient to Newark Bay is typical of large coastal estuaries and inshore waterways located along the Mid-Atlantic Bight. Situated in the transition zone between northern coldwater (boreal) and temperate (warm) water with low to moderate salinity, Newark Bay acts as a spawning ground, migratory pathway, and a nursery/foraging area for a variety of estuarine, marine, and anadromous fish species.

Essential fish habitat (EFH) exists for several finfish species, as documented in Environmental Impact Statements required for federal maintenance dredging (USACE 2004b, Undated). The EFH was extracted from NOAA's online EFH data mapper for the Hudson River/Raritan/Sandy Hook Bays area (http://www.nero.noaa.gov/hcd/est.htm). The entire bay is identified as EFH for one or more important life stages (i.e., eggs, larvae, juveniles, adults, and spawning adults) of 21 fish species (Table 3-3).

Many of the seasonally abundant fish species in Newark Bay are transient or migratory, passing through Newark Bay to upstream spawning grounds or entering the area seasonally from nearby ocean waters. These include estuarine migratory species, such as striped bass (*Morone saxatillis*), that depend on the estuary as a nursery and a forage area for juveniles and adults. Species that frequent Newark Bay during similar life history stages include both marine and estuarine predators, such as winter flounder, bluefish (*Pomatomus saltatrix*), and summer flounder (*Paralichthys dentatus*). These fish migrate in and out of Newark Bay seasonally depending on spawning area (estuarine vs. marine) and period (winter vs. summer) (U.S. Fish and Wildlife Service [USFWS] 1997; Woodhead 1991).

A few fish species are year-round residents in Newark Bay; these species generally begin spawning in late spring and continue throughout most of the summer following general onshore and offshore seasonal movement patterns (onshore in spring and summer, offshore to deeper waters in fall and winter). Most life stages of these species may be found in the estuary throughout the year. These species, such as the mummichog (*Fundulus heteroclitus*) and striped killifish (*Fundulus majalis*), provide an important forage base for larger predatory species.

Previous biological investigations have characterized the seasonal distribution and composition of the fish community in various habitats and areas of Newark Bay. NMFS conducted a major fish sampling program in Newark Bay as part of an evaluation of a flood control project for the Passaic River Basin (NOAA 1994). This study provides additional information on habitat preference of species (e.g., channel vs. shoal [subtidal] areas). Monthly fish sampling was conducted from May 1993 through April 1994. Juvenile and adult fish were sampled with bottom trawls and gill nets. A total of 56 species of fish and invertebrates were identified from 299 otter trawl tows, 105 shrimp trawl tows, and 92 gill net sets. The dominant species caught in the channels were striped bass and Atlantic tomcod (*Microgadus tomcod*). The dominant species caught in the shrimp trawl were bay anchovy, Atlantic herring (*Clupea harengus*), and Atlantic tomcod. The dominant species caught in the gill nets were Atlantic menhaden (*Brevooria tyrannus*) and striped bass. From the seven shoal stations on the east side of Newark Bay (relative to the main channel), 28 species of fish were collected with a bottom trawl. Six species – striped bass, winter flounder, bay anchovy, Atlantic herring, Atlantic tomcod, and Atlantic silverside (*Menidla menidla*) – dominated the catch from all shoal stations combined (USACE 2004b). Most species, whether resident or transient, were found throughout the extant range of habitat conditions. The notable exception is white perch (*Morone americana*), which was not collected in waters that had less than 6.23 milligrams per liter of dissolved oxygen (DO) (NOAA 1994).

In order to describe the species composition and relative abundance of fish in shoal areas of Newark Bay, Lawler, Matusky and Skelly Engineers, Inc. (LMS) conducted sampling trawls from April 1995 to March 1996 (LMS 1996). Four shoal areas in Newark Bay were sampled to provide information on the fish community. Species collected from the shoal stations were dominated by relatively few species. Eight species – bay anchovy, striped bass, winter flounder, windowpane flounder, Atlantic silverside, summer flounder, northern pipefish (*Syngnathus fuscus*), and white perch – dominated the catch at each station. Most species occurred infrequently and in very low numbers during the 12-month study. However, there was a consistent seasonal pattern for fish among the shoal stations. Fish were relatively abundant from April through October, but much less abundant from November through March. During the period when fish were most abundant, only four species – striped bass, winter flounder, summer flounder, and bay anchovy – occurred during each month.

Since 1998, USACE has collected fish community data from various stations in Newark Bay with a 30-ft otter trawl as part of the NY/NJ HDP. USACE notes that multi-year sampling programs are essential to establishing the use of channel and non-channel areas within the harbor from year to year. Sampling data can be used to describe annual variability in seasonal movement patterns, in usage and relative abundance, and to expand the temporal coverage of the program database. This sampling has provided a valuable long-term dataset to assess the response of fish communities to changing conditions and anthropogenic alterations in the harbor. In Newark Bay, species abundance has varied from year to year, but is generally dominated by a few species (e.g., white perch, striped bass, and bay anchovy). Data from the most recent 5 years of sampling (2005 through 2009) are presented on Figure 3-3.

The available fish community data collected in Newark Bay between 1993 and 2009 are summarized in Table 3-4. Data are presented as catch per unit effort and rounded to the nearest whole number. Direct comparisons of the studies are not possible because different gear types were used (gill nets vs. trawls) in different areas of Newark Bay (shoal vs. channel stations), the sampling efforts were substantially different, and some studies did not provide station information. However, the studies are useful for the identification of species, relative abundance, and seasonal occurrence of fish. Species composition among studies appears to be similar despite gear-type differences. Numbers of some species, such as American eel and mummichog, may be under-represented in these studies due to the types of fishing methods used. Success rates for capturing such species may be higher with appropriate minnow or eel traps, rather than tow/otter trawls or gill nets.

As shown on Figure 3-4, across 17 years of sampling, the following 11 species dominated the overall composition of Newark Bay finfish community: striped bass (21%), white perch (19%), bay anchovy (17%), Atlantic tomcod (8%), weakfish (6%), Atlantic herring and winter flounder (5%), spotted hake (4%) Atlantic menhaden (3%), alewife (2%), and blueback herring (1%). The remaining species represented less than 1% of the catch (Figure 3-4). The shortnose sturgeon (*Acipenser brevirostrum*), although federally listed as a protected species in Newark Bay, has not been documented in any of the studies in Newark Bay or adjacent waters (USACE 1997).

The seasonality of the finfish community is plotted on Figure 3-5, which shows the seasonal abundance for several species. For instance, striped bass appears to peak in the late fall (i.e., November). Both weakfish and bay anchovy peak in the late summer/early fall (i.e., September); Atlantic herring peaks around May. White perch is one of the few species that peaks in the winter. Although it appears that Atlantic tomcod peak in the summer, only five fish have been captured since 2005. The cause for the population decline is largely unknown, although investigators have speculated that the cause could be chemical contaminant concentrations (Fernandez et al. 2004; Wirgin 2004; Wirgin and Chambers 2006) and/or rising water temperatures (Daniels et al. 2005).

3.1.1.2 *Wetlands*

The NBSA wetlands shown on Figure 2-5 were classified based on their salinity (e.g., marine, estuarine, and freshwater) according to the USFWS National Wetlands Inventory Program. The dominant wetland type of the NBSA is estuarine/marine. Intertidal wetlands are sporadically observed on the west side of Newark Bay near the Newark Bay Bridge, along Kearny Point, on the southeastern side of Newark Bay just south of the Elizabeth Channel, and near the confluence with the Arthur Kill. A large, contiguous wetland habitat also exists along the eastern side of the Arthur Kill (Figure 2-5). Wetlands dominate the intertidal geomorphic region and provide refuge for a variety of organisms, including aquatic vegetation, which is discussed below.

Aquatic Vegetation

The intertidal wetlands (Intertidal Areas) of the NBSA primarily consist of emergent common reeds and saltmarsh cordgrass, with the cordgrass occupying lower portions of the shoreline, while common reeds are generally located further upland. A vegetation survey along the Lower Passaic River by the USACE in 2008 noted only 20 to 29% of herbaceous plant species and 60 to 80% of shrubs were native (USACE 2004a, 2005, 2006a, 2007a, 2008a, 2009); the remaining were non-native (Windward/AECOM 2009). Similar to the Lower Passaic River, there are likely both native and non-native species along the shoreline of the NBSA, but a vegetation survey has not been performed. In addition to vegetation, the NBSA supports a variety of phytoplankton and algal communities that are periodically surveyed, sampled, and characterized by the New Jersey Department of Environmental Protection (NJDEP 2009a). In 2005 as in previous years, the Hudson/Raritan estuary was dominated by a diverse assemblage of diatoms in mild to full bloom proportions. Dinoflagellates detected during this season were *Gyrodinium undulans*, *Olisthodiscus luteus*, and *Prorocentrum micans*. In addition, *Pseudonitzschia spp.* and *Dinophysis spp.*, both potentially toxic species, were detected below bloom or toxic concentrations (NJDEP 2008).

Reptiles and Amphibians

In freshwater wetlands, reptiles and amphibians are typically abundant. However, given the estuarine nature of the water of Newark Bay, amphibians, such as salamanders and frogs, are unlikely to be present (USFWS 1997). However, USACE (1997) notes the possibility that the diamondback terrapin (*Malaclemys terrapin*) could occur as a transient visitor to the NBSA as it moves between the Hackensack Meadowlands Complex and marshes and tidal creeks along the Arthur Kill. The diamondback terrapin is the only species of turtle in North America that spends its life in brackish water (National Aquarium 2010). No terrapins have been collected to date in bottom trawls, but they appear to be a pollution-tolerant species (Wood 1995, as cited in USACE 1997). USACE (1997) also notes the possibility for three species of marine turtles – loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), and the green sea turtle (*Chelonias mydas*) – to utilize the shoal areas (i.e., Subtidal Flats) of Newark Bay. However, there is no documented evidence of these species in the NBSA (Table 3-5).

3.1.1.3 *Forested Areas*

Shooters Island, located in the southern portion of Newark Bay, is one of the major forested areas of Newark Bay. It is partially wooded with species such as black locust (*Robinia pseudoacacia*), tree-of-heaven (*Ailanthus altissima*), and Japanese honeysuckle (*Lonicera japonica*). Small patches of saltmarsh containing common reeds and cordgrass occur around the island's shoreline, including scattered debris, rotting docks, abandoned buildings, shipwrecks, and barges (USFWS 1997). Despite its impacted condition, Shooters Island continues to serve as a bird sanctuary and refuge for migratory birds such as gulls, cormorants, and osprey, which have recently been observed on the island (Bernick and Craig 2008).

Additional forested areas occur along the eastern tip of Kearny Point, just south of the Elizabeth Marine Terminal, along the eastern side of Bayonne Park, and in Richard A. Rutkowski Park. Sporadic forested areas also occur between Veterans and City Parks, in Mariners Marsh, and around the Newark Bay Bridge (Figure 3-1).

Birds

Populations of birds that inhabit or utilize the forested (and other) areas of Newark Bay are mainly water birds, including waterfowl (ducks and geese), wading birds (herons and egrets), shorebirds (sandpipers, plovers, and oystercatchers), seabirds (gulls, terns, and cormorants), and birds of prey (osprey). Most of the water bird species found in the Newark Bay region (and NY/NJ Harbor Estuary as a whole) are migratory. The area is part of the Atlantic Flyway, a major north-south migration route that is used by migrant species as a seasonal stopover (Elphick et al. 2001). The birds utilize open waters of Newark Bay and the Intertidal Areas, feeding and resting for a few days to a few weeks en route to northern breeding grounds or southern wintering areas. Sandpipers, plovers, and their relatives are abundant migrants, and some are winter residents (Walsh et al. 1999).

Adequate nesting grounds are limited in the NBSA due to the highly urbanized shoreline of Newark Bay and its tributaries (i.e., the Passaic River, Hackensack River, Arthur Kill, and Kill van Kull). Therefore, most water birds primarily build their nests for breeding offshore on the 17 islands located within the NY/NJ Harbor Estuary. Three of the islands are located in the Arthur Kill/Kill van Kull complex (Shooters Island, Prall's Island, and Isle of Meadows). These islands and, to a lesser extent, mainland areas of the NY/NJ Harbor Estuary, have been surveyed for decades to quantify and characterize the nesting and trends in water bird populations.

In general, it appears that flight lines occur from colonies on various islands to the Hackensack Meadowlands Complex, which likely provides a variety of foraging habitats (marshes, mudflats, and tidal creeks) (Gelb 2004; USACE 1997). Overall, the breeding populations of water birds in the NY/NJ Harbor Estuary vary in abundance over time (Harbor Herons Subcommittee 2010). The top portion of Figure 3-6 shows the total number of nests for 10 species of water birds documented between 2001 and 2009. Because all 17 islands were not surveyed each year, the bottom portion of Figure 3-6 shows the number of nests normalized to the number of islands surveyed each year, better reflecting the annual variability.

Wading birds can be found foraging in mudflats along the Lower Passaic and Hackensack Rivers and in tidal marshes within the region (Iannuzzi and Ludwig 2004; Ludwig et al. 2010; Windward 2011). They are not expected to be a major component of the bird fauna of the relatively restricted confines of Newark Bay, but they do likely forage on the few intertidal mudflats of Newark Bay. On the other hand, seabirds and birds of prey are able to utilize the entire NY/NJ Harbor Estuary, including Newark Bay, for foraging (USFWS 1997). Only a few waterfowl species are known or suspected of breeding in Newark Bay (Walsh et al. 1999).

Bird species observed in the NBSA from several bird surveys that have been conducted since 1990 are identified in Table 3-6. The list, originally provided in the Inventory Report (Tierra 2004) and further documented by Ludwig et al. (2010), has been updated to include more recent bird surveys that have been conducted in the region; notably, the Harbor Herons Project survey data collected in 2004, 2007, and 2008, as well as the Hackensack Meadowlands District data collected from 2004 through 2005 (Bernick 2007; Bernick and Craig 2008; Kerlinger 2004; Mizrahi et al. 2007). The majority of bird species were observed in the Hackensack River (248), including the Meadowlands District; followed by the Arthur Kill (213), including Prall's Island and Isle of Meadows; Newark Bay (81), including Shooters Island; Kill van Kull (59); and the lower 6 miles of the Passaic River (49).

Results of the 2010 summer bird survey of the Lower Passaic River performed by the CPG indicate more aquatic and semi-aquatic bird species observed than during the summer 2000 survey (Ludwig et al. 2010): 21 species were observed in summer 2000, whereas 28 species were observed in summer 2011 (Windward 2011). Similar numbers of species were observed in fall 1999 and fall 2010: 22 species in fall 1999 and 23 species in fall 2010. Gulls were the most commonly observed birds in the fall (1999) and summer (2000), followed by swans, geese, ducks, wading birds, and shorebirds (Ludwig et al. 2010; Windward 2011).

The Natural Heritage Programs of NJDEP and the New York State Department of Environmental Conservation (NYSDEC) have identified and observed 12 rare and protected bird species in the NBSA (refer to Section 3.1.2).

Mammals

Mammals most likely to inhabit the NBSA are human-tolerant species that are commonly found in urban environments, such as squirrels, raccoons, rabbits, bats, and possum (USACE 1997; USEPA 2008b). The likelihood of any of these animals foraging directly from NBSA waters or the minimal available shoreline is limited, as they would likely remain in the terrestrial habitat.

There is limited available aquatic habitat for marine mammals, such as cetaceans, in the NBSA. In addition, the noise and traffic of cargo ships entering and leaving Newark Bay would likely deter these animals from intentionally entering it. As discussed by USEPA (1997) and in the SLERA (USEPA 2008a), the possibility of cetaceans entering Newark Bay is remote.

USACE (1997) identified nine species of bats, a muskrat (*Ondatra zibethica*), and a harbor seal (*Phoca vitulina*) as "possible" species utilizing the Subtidal Flats of Newark Bay (Table 3-5). In addition, the river otter (*Lontra canadensis*) is a common inhabitant of the Hudson River and the NY/NJ Harbor Estuary. Although commonly called a "river" otter, the name can be misleading, as the animal inhabits marine, as well as freshwater environments, and some populations permanently reside in marine shoreline habitats. The North American river otter is found in a wide variety of aquatic habitats, both freshwater and coastal marine, including lakes, rivers, inland wetlands, coastal shorelines and marshes, and estuaries. The river otter's main requirements are a steady food supply and easy access to a body of water. However, the North American river otter is sensitive to pollution and will avoid tainted areas (Dewey and Ellis 2003).

3.1.1.4 *Urban Landscape*

Urban areas of the NBSA are covered by bulkheads, rip-rap, buildings, and pavement and are shaded gray on Figure 3-1. These areas limit the available wildlife habitat, such as nesting and foraging areas for birds. The vast extent of impervious surface (i.e., pavement and concrete) decreases stormwater infiltration and shunts concentrated volumes of stormwater runoff directly into Newark Bay and its tributaries.

Within the urban areas, there are several parklands and public recreational areas for active or passive use (Figure 3-1). The active facilities are designed for activities such as field sports, jogging, and children’s play, whereas the passive facilities are intended for activities such as strolling, reading, sunbathing, sitting, bird watching, or dog walking. In many cases, the parklands and public recreation areas can be used for either active or passive recreation.

3.1.1.5 *Barren Land*

Barren land (Figure 3-1) consists of recently cleared or disturbed areas where soils have been disturbed (coal cinders are often a major soil constituent). Vegetation consists of tolerant, often introduced, species. Vegetation is present in scattered patches, offering little cover for wildlife, particularly in winter. Garbage and debris items are present in the vacant lots/fields. Typical plant species include goldenrod (*Solidago canadensis* or *Solidago virgaurea*), mugwort (*Artemisia vulgaris*), raspberry (Rubus), Asian bittersweet (*Celastrus orbiculatus*), pokeweed (*Phytolacca americana*), and saplings of royal paulowina (*Paulownia tomentosa*), mulberry (*Morus* spp.), tree-of-heaven, and black locust. Typical wildlife observed includes terrestrial, urban-tolerant species (United States Coast Guard 2010).

3.1.2 Population Data

3.1.2.1 *Threatened and Endangered Species*

The state and federally listed threatened and endangered species for the NBSA are documented in Appendix A. To identify these species, a request was submitted to the National Heritage Program for the State of New Jersey, and an online search using NYSDEC's Nature Explorer was conducted with a user-defined subject area for the State of New York. The online search area consisted of the southern portion of Newark Bay and portions of the Kills, which are the areas of Newark Bay that fall under New York state jurisdiction. The listed species consist mainly of birds, but also includes three insects, one plant, and one fish species. The State of New York also lists two habitats. The only federally endangered species is the shortnose sturgeon. The species and habitats are identified below.

Exhibit 3-1 Threatened and Endangered Species in the NBSA

Species	Common Name	Federally Listed	State Listed
Birds			
Nycticorax nycticorax	Black-crowned night heron		NJ
Bubulcus ibis	Cattle egret		NJ, NY
Plegadis falcinellus	Glossy ibis		NJ, NY
Sterna antillarum	Least tern		NJ
Egretta caerulea	Little blue heron		NJ, NY
Pandion haliaetus	Osprey		NJ
Falco peregrines	Peregrine falcon		NJ
Egretta thula	Snowy egret		NJ, NY
Egretta tricolor	Tricolored heron		NJ
Nyctanassa violacea	Yellow-crowned night heron		NJ, NY
Ardea alba	Great egret		NY
Tyto alba	Barn owl		NY
Insects			
Pontia protodice	Checkered white butterfly		NJ
Somatochlora linearis	Mocha emerald dragonfly		NY
Ischmura ramburii	Rambur's forktail damselfly		NY

Species	Common Name	Federally Listed	State Listed
Plants			
Elocharis quadrangulata	Angled spikerush		NY
Fish			
Acipenser brevirostrum	Shortnose sturgeon	X	NJ
Habitats			
Colonial Waterbird Nesting Area			NY
Gull Colony			NY

Note: Refer to Appendix A.

3.1.2.2 *Humans*

Human use activities in the NBSA are dictated by a variety of factors, including shoreline type (e.g., bulkhead, bridges, and sheet piling), land use (e.g., industrial, commercial, and residential), public access areas, and waterway use (e.g., shipping and fishing). The primary human uses of the NBSA include commercial activities (e.g., shipping, commerce, and industrial and municipal infrastructure and use) and recreational activities (e.g., fishing and shoreline use). Recreational fishing and shellfish collecting are recognized activities that are expected to result in the highest potential for exposure to chemicals in the NBSA (Burger 2002, 2003). Current and future land-use evaluations were performed for the NBSA. A summary of results is presented below. Additional descriptions of the evaluations are provided in Appendix B. Appendix C contains photographs and descriptions that depict additional site reconnaissance in the residential areas near Newark Bay. The photographs in Appendix C show the lack of Newark Bay access at various points near residential areas.

Current Land Use Evaluation

The NBSA is a very large site with mixed human uses. Thus, all land with boundaries comprising the shoreline of the NBSA was evaluated for the potential for humans to contact environmental media (i.e., sediment and surface water) under current use conditions. Categories of shoreline accessibility were generally based on the following: 1) if the land was zoned or used for industrial (associated with limited accessibility) or non-industrial (greater potential for accessibility) purposes, and 2) classified by the type of access as follows:

- Industrial/Manufacturing – No Access – An area of shoreline that is zoned for industrial or manufacturing purposes and has no readily available access to sediment by humans.

- Industrial/Manufacturing – With Access – An area of shoreline that is zoned for industrial or manufacturing purposes that provides access to the sediment by humans.

- Non-Industrial – No Access – A non-industrial zoned area of shoreline that does not present access to sediment due to physical boundaries such as fences or steep slopes.

- Non-Industrial – With Recreational Access – A non-industrial zoned area of shoreline that provides the possibility of recreational access to sediment. The public could access NBSA sediment and surface water for activities such as wading, swimming, boating, canoeing, and fishing or crabbing.

- Non-Industrial – With Residential Access – A non-industrial zoned area of shoreline that provides the possibility of residential access to sediment, with residential access defined as exposure 350 days per year for 30 years.

Appendix B contains a detailed description of the current land use and site access evaluation process, and Appendix C provides details regarding on-site reconnaissance activities. Exhibit 3-2 below summarizes the results of this evaluation.

Exhibit 3-2 Summary of Exposure Characterizations – Current Land Use

Characterization	Total Length (miles)	Percentage of Total Perimeter (%)
Industrial/Manufacturing – No Access	14.2	52
Industrial/Manufacturing – With Access	5.9	22
Non-Industrial – No Access	3.3	12
Non-Industrial – Recreational Access	3.9	14
Non-Industrial – Residential Access	0	0
All characterizations	27.3	100

Note: Refer to Appendix B for details.

Future Land Use Evaluation

Four areas along the perimeter of the NBSA have the potential to undergo future residential development. These areas were identified on regional zoning maps and further investigated by reviewing development plans from the respective cities or counties surrounding the NBSA (City of Bayonne 2000, 2001, 2003; City of Elizabeth 2012; City of Newark 2004; Hudson County 2010; Jersey City 2001, 2008; City of Kearny 2009; New York City 2011a, 2011b; Schoor DePalma, Inc. 2005). The objective of this review was to determine if there are any differences between current and future land use with respect to potential exposure to sediments. A more detailed description of the future residential developments can be found in Appendix B. Exhibit 3-3 below summarizes the areas identified for potential future residential development and shoreline access.

Exhibit 3-3 Areas Slated for Alternative Future Development (Including Residential)

Zone	Length (miles)	Current Shoreline Access Characterization	Potential Future Use (and Shoreline Access Characterization)
Bayfront I Redevelopment Zone	0.2	Industrial/Manufacturing – No Access	Mixed-use residential, retail, parks or recreation, and commercial area (non-industrial area with no access)
Waterfront Development District	0.8	Industrial/Manufacturing – With Access	Mixed-use residential, parks, and commercial area (non-industrial area with recreational access)
Kapkowski Road Redevelopment Area	1.0	Industrial/Manufacturing – With Access	Mixed-use residential and commercial area (non-industrial area with recreational access)
Staten Island – North Shore	NA	Industrial/Manufacturing – With Access	Currently planned for mixed-use recreational and commercial (non-industrial area with recreational access)

Notes:
NA = not applicable

In summary, there appears to be no difference between current and future land use with regard to site access. Some industrial properties and some potential recreational areas are situated such that humans could have direct access to NBSA environmental media. However, no residential properties were identified under current land use or appear likely in the future that will provide access 350 days per year to environmental media such as sediments.

3.2 Quantitative Data

Apart from sediment data, few other quantitative analytical chemistry data have been collected from the NBSA. Table 3-7 presents a preliminary summary of available data from third-party sources that have been reviewed and are considered relevant and acceptable for quantitative or semi-quantitative use in the risk assessments, as discussed below.

3.2.1 Secondary Data Evaluation

An evaluation of all secondary data sources is being conducted to evaluate the quality and usability of data collected by third parties. USEPA identified numerous secondary data sources considered potentially relevant to the NBSA data assessment process (E. Butler, email correspondence, May 16, 2008). These data sources, and any additionally identified data, are being reviewed as part of the secondary data evaluation. The overall objective of this evaluation is to identify how the data provided in individual source documents can be used to fulfill each of the three RI goals: nature and extent of contamination, risk assessment, and/or source identification.

Data sources being reviewed include government studies, academic theses, peer-reviewed journal articles, and independent studies. Risk assessment-related data generally include biological tissue concentration data and/or bioaccumulation data for metals, PAHs, PCBs, pesticides, PCDDs, and PCDFs and surficial sediment chemistry, population metrics (e.g., richness and abundance), and toxicity data. The review of each data source involves a step-wise process that ultimately leads to a usability classification:

1. Level 1 (Qualitative) – Data have limitations and should only be used for qualitative purposes in the risk assessments.

2. Level 2 (Semi-Quantitative) – Data have some limitations, but could be used on a semi-quantitative basis in the risk assessments, as appropriate.

3. Level 3 (Quantitative) – Data are considered appropriate for quantitative use in the risk assessments.

Descriptions of major datasets preliminarily deemed reliable for semi-quantitative and quantitative use (i.e., considered Levels 2 or 3) in the baseline risk assessments are provided in the following sections.

3.2.2 Sediment Data

The USEPA (2004) AOC identified various hazardous substances in NBSA sediments that may pose a risk to human and ecosystem health. These chemicals of interest include, but are not limited to, cadmium, copper, lead, mercury, nickel, zinc, PAHs, PCBs, dichlorodiphenyltrichloroethane (DDT), 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), 2,4-dichlorophenoxy acetic acid, 2,4,5-trichlorophenoxy acetic acid, and 2,4,5-trichlorophenol. As part of the sediment investigations (Phase I and Phase II Sediment Investigations [SIs]) conducted under this AOC and associated RI program, sediment core locations across the NBSA were sampled for various analytes, including pesticides, PCBs (as Aroclors, congeners, and homologues), SVOCs, metals, cyanide, chlorinated herbicides, dioxins/furans, and total petroleum hydrocarbons. A limited number of VOCs were also analyzed, including chlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, 1,2,4--trichlorobenzene, and 1,2,3-trichlorobenzene (Tierra 2005, 2007). Collectively, chemical analyses were performed for 366 individual chemicals or chemical groups in the Phase I and Phase II SIs, providing an abundance of data for these chemicals of interest (Tierra 2010a, 2010b).

In addition to the chemicals recognized in the AOC, there are a substantial number of additional chemicals that may be present in the NBSA, including but not limited to, emerging contaminants associated with pharmaceuticals, personal care products, and flame retardants. For example, USEPA has identified the following chemicals as potential emerging chemicals of concern in the environment: bisphenol A; phthalates; perfluorinated chemicals; penta-, octa-, and decabromodiphenyl ethers; short-chain chlorinated paraffins; benzidine dyes; diisocyantes; nonylphenol and nonylphenol ethoxylates; and siloxanes (USEPA 2010b). Some of these emerging chemicals have already been identified in the NBSA. For example, an SI conducted by the NYSDEC for the Contaminant Assessment and Reduction Project (CARP) detected polybrominated diphenyl ethers (PBDEs; flame retardants) in Newark Bay sediments (NYSDEC 2003). In conjunction with Phase II activities, polychlorinated naphthalenes (PCNs) and PBDEs were also found to be present in sediment throughout the NBSA (Tierra 2010b). In an effort to be consistent with USEPA guidance (USEPA 2001a), the RI will include an evaluation of some emerging chemicals; those that are identified will be addressed in the BERA and BHHRA.

3.2.2.1 *Sediment Chemistry Data*

Sediment samples have been collected in Newark Bay since 1990 and analyzed for various parameters, including metals, PAHs, PCBs, pesticides, herbicides, VOCs, SVOCs, PCDDs, PCDFs, TOC, grain size, radiochemistry, and acid volatile sulfides/simultaneously extracted metals (AVS/SEM). Sediment core data are available across the NBSA for sediment depths ranging from 0 to 29.5 ft below sediment surface and from surficial sediment grab samples.

The most recent and comprehensive large-scale sediment sampling in the NBSA was conducted by Tierra in 2005 and 2007 under the RI program (the Phase I and Phase II SIs, respectively). Collectively, these sediment sampling events collected and analyzed over 640 surface and subsurface sediment samples from 119 locations in the NBSA, providing data for 366 individual chemicals or chemical groups. These data provide important insight on the horizontal and vertical distribution of COPECs and COPCs throughout the NBSA sediment. These data are available in Tierra 2008b, 2010a, and 2010b.

The risk assessments will focus on the BAZ, which has been established as the top 15 cm (approximately 6 inches or 0.5 ft) of surface sediment (Tierra 2008a). In order to utilize data that may best represent the current/recent BAZ (i.e., chemistry within the top 6 inches of the sediment bed) and to maintain consistency with other ongoing programs in Newark Bay, only analytical chemistry data collected since 2000 will be quantitatively utilized for risk assessment purposes.

3.2.2.2 *Sediment Toxicity Data*

Fourteen laboratory studies have documented sediment toxicity within Newark Bay and its tributaries (Tierra 2004). Various organisms were used to measure survival and growth, including amphipods (*Ampelisca abdita* and *Rhepoxynius abronius*), polychaetes (*Armandia brevis*), mysids (*Mysidopsis bahi*a), bivalves (*Mulina lateralis*), and sand dollars (*Dendraster excentricus*). In general, the studies showed that, with the exception of *A. abdita*, the organisms were not sufficiently sensitive, from either a growth or survival aspect, to evaluate differences in toxicity of various sediments.

The amphipod *A. abdita* is the most widely used organism in sediment toxicity studies in the NY/NJ Harbor Estuary; the NBSA results are shown in Table 3-8 and on Figure 3-7. Eighty-five individual survival toxicity tests have been conducted using *A. abdita* (Figure 3-7), 55 of which (65%) exhibited toxicity (defined as percent survival significantly less than control). Results from one of the largest programs, USEPA's REMAP, indicated that an estimated 50% of Newark Bay is toxic to amphipods (samples from the Arthur Kill were also included in this estimate) (USEPA 1998, 2003b). NOAA (1995) estimated 85% of the Newark Bay region is toxic (area included the Lower Passaic River, Hackensack River, and Kills). Both the REMAP and NOAA studies used a stratified random design to estimate the areal extent of toxicity.

3.2.3 Tissue Data

3.2.3.1 *Tissue Chemistry Data*

Fish and other biota tissue sampling for contaminant characterization is limited for the NBSA. During the 1980s, NJDEP captured and analyzed fish for PCBs and pesticides from edible fillets (NJDEP 1982, 1983, 1985). Also during the 1980s, Brown et al. (1994) and Rappe et al. (1991) collected dioxin/furan data from various fish and shellfish tissue in Newark Bay. Most recently, CARP captured and analyzed tissue data from one location in the center of Newark Bay (NYSDEC 2004a, 2004b, 2004c, 2005, 2006). Tissue data from CARP are available for the following seven fish species and associated matrices:

- American eel: whole body minus head and viscera
- Blue crab: all edible tissue, hepatopancreas, and muscle tissue
- Mummichog: whole body
- Ribbed mussel (*Geukensia demissa*): all soft parts
- Sevenspine bay shrimp (*Crangon septemspinosa*): whole organism
- Striped bass: liver tissue and standard fillets
- White perch: standard fillets, whole body minus head and viscera, and whole body.

Additional data are available for polychaetes and zooplankton greater than 64 microns. All tissue data were analyzed for metals, PAHs, PCBs, pesticides, PCDDs, and PCDFs (Table 3-7). Length, weight, and percent lipid data were also collected for four fish species, bivalves, and blue crabs (Exhibit 3-4).

Exhibit 3-4 Length, Weight, and Percent Lipid Data for Species Captured Under CARP

Species	Average Length (mm)	Average Weight (g)	Average Percent Lipid (%)
Mummichog	64	64	2
White perch	218	167	5
American eel	544	420	17
Striped bass	562	2160	3
Bivalves	59	20	1
Blue crab muscle	140	152	5
Blue crab hepatopancreas	140	152	9
Blue crab – all edible	142	149	2

Notes:
mm = millimeter
g = gram

Tissue data were also collected from Newark Bay for the New Jersey Routine Monitoring Program for Toxics in Fish (Horwitz et al. 2006). Under this program, three samples of blue crab muscle and hepatopancreas tissue were collected from crabs at two stations located in Newark Bay, one at Shooters Island and one at Turnpike Bridge (Table 3-7).

A study by Parsons (2003), also conducted under the CARP program, analyzed samples of double-crested cormorant eggs, blood, and feathers for various chemical parameters from three islands throughout the NY/NJ Harbor Estuary. The objectives of the study were to determine if concentrations of chemicals were present in the birds at levels of concern, and to determine if there was any correlation between the concentrations of the chemicals and reproductive success in the population. Results indicated that tissue samples collected from birds on Shooters Island, in general, had higher concentrations of chemicals than tissues collected from birds on the other two islands (Swinburne and Gardiners). However, no correlation could be made between reproductive success and chemical concentrations among the three islands.

Additional studies (e.g., Cooper and Buchanan 2007; Bugel 2009, 2011; Gale et al. 2000) have collected biomarker data such as external examinations, blood smears, hematocrit, total and organ weights, histopathology, biochemical endpoints, including endocrine disruption (e.g., ethoxyresorufin-O-deethylase induction), and fluorescent activity. These data attempt to document potential changes in fish at the molecular level; however, it is difficult to scientifically link alterations in biomarkers to particular constituents.

3.2.3.2 *Bioaccumulation Studies*

Four studies documented bioaccumulation in benthic invertebrates within Newark Bay and its tributaries (Tierra 2004). Some studies calculated accumulation factors but did not present the raw data. In addition, two other benthic bioaccumulation studies have been reviewed: one for the CARP program (Hydroqual 2007) and one by USACE (2010a).

As part of the CARP program, co-located sediment and polychaete samples were collected and analyzed from seven locations in the NY/NJ Harbor Estuary, and biota-sediment accumulation factors (BSAFs) were calculated for two subgroups (inner and outer harbor) (Hydroqual 2007). BSAFs for the inner harbor (Upper Bay, Newark Bay, and Arthur Kill) were calculated, but there is a high level of uncertainty associated with these values.

The USACE conducted laboratory bioaccumulation tests and kinetic modeling using Newark Bay and Arthur Kill sediment with the polychaete, *Nereis virens*, and the clam, *Macoma nasuta* (USACE 2010a). The study found that the standard 28-day exposure duration was generally adequate to achieve equilibrium for *N. virens* but not for *M. nasuta*.

3.2.3.3 *Tissue Ingestion Data*

It is expected that the consumption of fish and/or shellfish from the NBSA poses the most significant potential for exposure by humans to chemicals in NBSA environmental media (USEPA 2000a, 2005c); thus accurate characterization of this pathway is important for reducing uncertainty in the BHHRA. A review of existing pertinent information related to human use activities and creel/angler surveys in and around the NBSA is provided below.

<u>Human Activities Related to Crab and Tissue Ingestion</u>

A human use survey of the NBSA was conducted by Burger (2003) as part of a study that documented the public's perception of the most significant environmental concerns in the area and the most important environmental improvements. Different forms of recreational use of Newark Bay were ranked from 1 to 5 (1 being the least important and 5 being the most important). Results indicated that swimming is least important (average ranking of 1.3), fishing/crabbing are moderately important (2.6 to 2.9), and “commune with nature/enjoyment of a place without people” was ranked highest (3.5 to 3.6). With regard to potential restoration opportunities in Newark Bay, the public showed the greatest desire (3.8) for creating more breeding fish habitat.

Additionally, there have been observations of people fishing and crabbing along the Bayonne waterfront, on the eastern side of the NBSA, from piers, exposed rocky shorelines, docks, and pilings, including the pilings of the Central Railroad of New Jersey Newark Bay Bridge that was demolished in the 1980s (Anglerweb.com, accessed August 3, 2010 [Exhibit 3-5]). It is important to note that these activities have been observed despite fishing advisories. Because of the presence of chemicals in NBSA biota, the general public is currently advised not to eat any blue crab, American eel (*Anguilla rostrata*), or white perch from the NBSA (NJDEP and New Jersey Department of Health and Senior Services [NJDHSS] 2012). The lack of adherence to these advisories may in part be because the waters of the NBSA are classified as marine, which does not require anglers to have a fishing license; therefore, they do not receive the fishing publication, Fish and Game Digest, which lists the state’s consumption advisories (Pflugh et al. 1999).

Exhibit 3-5 Observations of Recreational Fishing, Boating, and Crabbing in Newark Bay

Creel/Angler Surveys

There have been four major creel/angler surveys for the area in and around the NBSA: May and Burger (1996), Pflugh et al. (1999), Burger et al. (1999), and Burger (2002). NJDEP also conducted more recent crab/angler surveys in 2002 and 2005, and these data are analyzed in Pflugh et al. (2011). Brief summaries of these studies are provided below, and these data will be considered in the development of site-specific exposure factors for the human health risk assessment.

May and Burger (1996) interviewed 318 people from May to September 1994 along the shore and on party boats in the Arthur Kill, Raritan Bay, and at two unspecified locations along the New Jersey shore. The survey examined the consumption habits of anglers at these sites, whether the anglers were aware of the fish consumption advisories, how the anglers perceived the risk of eating fish caught from the sites, whether the anglers were exposed to toxic substances in fish, and whether their risk perceptions matched the severity of the hazard. Results showed that the frequency of fishing was highest in the Arthur Kill, averaging over eight times per month. Although 60% of anglers and crabbers in the Arthur Kill reported hearing warnings about consuming fish from these waters, 70% of anglers and 76% of crabbers said that they consumed their catch.

Pflugh et al. (1999) conducted interviews between July and October 1995 with 300 anglers at 26 unspecified fishing and crabbing sites around the NBSA. Data were collected on the six species under a state fish consumption advisory for recreational fishing: blue crab, striped bass, American eel, white catfish (*Ameiurus catus*), white perch, and bluefish. Results provided information regarding anglers' knowledge and belief in fish advisories, perceptions on the safety of consumption, and sources of information about fish and fish consumption advisories. Burger et al. (1999) also published a paper that evaluated the effect of ethnicity on the results of the Pflugh et al. (1999) study. They found that there were ethnic differences in consumption rates and knowledge regarding the safety of ingesting the fish tissue and awareness of fish advisories.

Burger (2002) reported the results from interviews with 267 people observed angling at several locations within the Newark Bay Complex between May and September 1999. One survey location was in the NBSA, one in the Hackensack River, one in the Passaic River, one in the Kill van Kull, and one in the Arthur Kill. The primary objective of the study was to relate the sociological reasons that people fish to their consumption patterns. The survey addressed demographics, consumption behavior (including information regarding serving size), knowledge of advisories, and reasons for angling. Of those interviewed, 111 people reported consuming only fish (44%), 110 people reported consuming only crab (44%), and 33 people (12%) reported consuming both fish and crab. No information was asked regarding species, parts consumed, preparation or cooking practices, or sharing. Based on the meal size and frequency data, Burger (2002) estimated mean consumption rates for fish-only consumers (22 grams per day [g/day]), crab-only consumers (15.6 g/day), and both fish and crab consumers (37 g/day of fish and 17 g/day of crab). More than 30% of anglers interviewed did not eat their catch and were not included in the calculation of consumption rates. There was wide variation in consumption patterns within each ethnic group (White, Black, Hispanic, Asian), but the study found no ethnic differences in reasons for fishing. Most people fished and/or crabbed for recreation; people rated ‘‘angling to obtain food’’ relatively low as a reason for fishing. Examples of species of finfish commonly caught for human consumption from the NBSA included white perch, striped bass, bay anchovy, Atlantic herring, bluefish, American eel, and various species of flounder.

Pflugh et al. (2011) reviewed and summarized crabbing surveys conducted by the NJDEP in 1995, 2002, and 2005 for the Newark Bay Complex, using the collective data to conclude that crabbing for recreational purposes and for dietary supplementation was occurring despite fishing and crabbing bans. The surveys provided data on the duration, frequency, and amount of crab consumed.

3.2.4 Surface Water Data

Outfalls serve as a continuing source of contaminants into the NBSA surface water and sediments. Chemical contributions from outfalls will be characterized during the RI/FS to understand their impact on the NBSA and their contribution to human health risks. During the June 2011 Baseline Human Health and Ecological Risk Assessment (BHHERA) Workshop, it was decided that exposure to pathogens would not be addressed in the NBSA Human Health Risk Assessment (HHRA) (ARCADIS and ToxStrategies 2011).

3.2.4.1 *Surface Water Chemistry Data*

Only a limited amount of chemical contaminant data has been collected for surface water from Newark Bay. For example, analytical chemistry data collected during the 1999-2006 Honeywell International Sampling Program are limited to metals, including hexavalent chromium (Table 3-7). A key difficulty in contaminant characterization sampling for surface water is the ability to achieve detection limits low enough to support risk assessments. Furthermore, because the surface water ingestion pathway is generally considered minor in terms of contaminant uptake, most sampling programs concentrate their efforts on collecting sediment.

Water column samples were collected under the CARP program and analyzed for various analytes, including metals (cadmium, lead, mercury, methylmercury, and silver), at five locations in Newark Bay between 1998 and 2000 (NYSDEC 2003).

Surface water sampling is currently being conducted in Newark Bay and the Lower Passaic River. AECOM’s (2011) Small Volume Chemical Water Column Monitoring data were collected in 2011 and 2012 from eight stations within Newark Bay and analyzed for over 200 chemical and physical parameters. In addition, data for the High Volume Chemical Water Column Monitoring program are also anticipated. These data are being collected under a variety of flow conditions and tidal phases to aid in characterizing the variability in fluxes and mixing processes in the NBSA. The data will be evaluated for risk assessment purposes and additional data will be collected, as appropriate, to fulfill risk assessment needs.

3.2.4.2 *Surface Water Quality Data*

Various programs (e.g., NOAA 1994) have collected non-chemistry surface water quality data from the NBSA, including DO, pH, salinity, temperature, conductivity, turbidity, and pathogens. The 2006 Regional Summary of Water Quality in the Newark Bay Area indicated high levels of fecal coliform and low levels of DO in bottom waters of Newark Bay (New Jersey Harbor Dischargers Group 2008). These parameters are also being collected in Newark Bay as part of the surface water monitoring program for the Lower Passaic River.

4. Baseline Ecological Risk Assessment

The BERA, consisting of Steps 3 through 7 of USEPA's Eight-Step ERA process (USEPA 1997), builds on the results of the SLERA to provide a more accurate and realistic estimate of potential ecological risk in the NBSA. To do this, various site-specific data are collected, toxicity tests are conducted, and potential risks to wildlife are estimated using refined food web exposure models. Results of the BERA are then used to manage ecological risks by informing the remedial action decision-making process in Step 8 of the ERA process.

4.1 Refinement of COPECs

The first step in the BERA process is to refine the COPECs that were originally identified in the SLERA based on any new data and any recently updated toxicologically based screening benchmarks.

4.1.1 Summary of COPECs from SLERA

The SLERA utilized data collected between 1990 and 2005 to compare maximum concentrations of constituents in sediment and tissue (i.e., fish, benthic invertebrates, crabs, mollusks, and avian embryos) to conservative ecological screening benchmarks to obtain a hazard quotient (HQ). Ecological screening benchmarks were identified for each distinct environmental media (sediment and biological tissue) and for each relevant exposure pathway. The screening benchmarks for sediment were based on the lowest of various published benchmarks (e.g., NYSDEC, NJDEP, and USEPA).

For those constituents considered bioaccumulative (USEPA 2000b), wildlife protective concentration levels were back-calculated for sediment and tissue using conservative exposure assumptions to be protective of bioaccumulative hazards to upper trophic-level receptors. In addition, a tissue screen was performed by comparing tissue concentrations to available literature-based critical body residue (CBR) values. As a result of the screening process, many constituents were identified as COPECs in sediment, fish tissue, mollusk tissue, crab tissue, benthic invertebrates, and avian embryos. Constituents with HQs greater than 1 were retained as COPECs to be further evaluated in the BERA. A summary table of COPECs in each exposure medium is presented in Table 4-1.

4.1.2 Updated COPEC Screen

Additional sediment data have been collected in Newark Bay since the SLERA was conducted in 2008 during the Phase I and II SIs (Tierra 2010a). The COPEC screen for surficial sediment (0 to 0.5 ft) has been updated to incorporate these new data (Table 4-2).

Datasets for the updated COPEC screen are limited to the last 12 years (i.e., 2000 to present) because it is likely that chemical concentrations in surface sediments of older datasets are no longer considered surficial. Furthermore, only data preliminarily classified as Level 3 by the secondary data evaluation review are incorporated into the COPEC screen. These data are applicable to the study area (i.e., located within 2 miles of the study area boundaries), have undergone quality assurance/quality control methods, been peer-reviewed, and have been validated according to USEPA Region 2 standards. As such, they are deemed rigorous and robust and can be utilized quantitatively in the baseline risk assessments.

The complete dataset for the updated surficial sediment COPEC screen consists of data collected from the Honeywell International Sampling Program (1999-2006) and the Newark Bay Phase I and Phase II SIs (Tierra 2010a). The dataset consists of over 200 constituents, plus individual congeners of PCBs, PCNs, and PBDEs. The sample size varies for each constituent, from three samples (for pyridine) to 258 samples (for chromium). Additional datasets from CARP (NYSDEC 2003) and USACE (2010a) were identified as Level 2 and were, therefore, not incorporated into the screen.

Ecological screening values for sediment were selected preferentially from values recommended by the Partner Agencies, which include ones developed for the LPRRP. These values were supplemented with: 1) current NJDEP Ecological Screening Criteria (ESC) for marine sediment (NJDEP 2009b), 2) current NJDEP ESC for freshwater sediment (NJDEP 2009b), 3) Region 3 benchmarks for marine sediment (USEPA 2006c), 4) Region 3 benchmarks for freshwater sediment (USEPA 2006d), and 5) Region 5 Ecological Screening Levels for sediment (USEPA 2003c).

A surface water COPEC screen has not been conducted due to the limited amount of currently available surface water data from the study area, as presented below.

Exhibit 4-1 Available Surface Water Datasets for Newark Bay

Date	Sampling Event	Secondary Data Level	Number of Stations	Number of Samples	Number of Analytes	Notes
1999-2006	Honeywell International Sampling Programs	3	56	92	2 - 8	Number of analytes varies by sample; only analyzed for metals and hexavalent chromium; results for total and filtered samples.
2000-2004	CARP NJ Surface Water Program	2	4	165	1 - 192	Number of analytes varies by sample.
2000-2004	CARP NY Surface Water Program	2	1	48	1 - 561	Number of analytes varies by sample.
2012	CPG Chemical Water Column Monitoring – Event 1	3	7	106	550	Number of analytes varies by sample.
2012	CPG Chemical Water Column Monitoring – Event 2	3	8	101	224	Number of analytes varies by sample.
2012	CPG Chemical Water Column Monitoring – Event 3	3	8	64	473	Data have been validated; final validated results not available. Number of analytes varies by sample.
2012	CPG Chemical Water Column Monitoring – Event 4	3	8	~100	~220	Data have been collected; final validated results not available.

4.1.3 Revised Sediment COPEC Screen Results

Table 4-2 presents the results of the updated surficial sediment COPEC screen. For detected constituents that have an ecological screening value for sediment, 89 of them have maximum concentrations that exceed their respective screening value and are considered COPECs. Of those 89, 73 constituents have mean concentrations that also exceed their respective screening benchmarks.

An additional 39 constituents were not detected in surficial sediment, but the maximum detection limits exceed the respective screening value; 28 of these constituents also have mean concentrations that exceed their screening values. This represents some uncertainty in the COPEC screen.

COPECs are similar to those identified in the SLERA (USEPA 2008a) and include individual constituents from various classes of chemicals (e.g., dioxins/furans, metals, pesticides, PCBs, SVOCs, PAHs, and a few VOCs). Summaries of COPEC fate and transport and ecotoxicity are provided in Sections 4.1.4 and 4.1.5, respectively. Due to the large number of COPECs, the discussions are based on COPEC groups, as opposed to individual COPECs.

4.1.4 Constituent Fate and Transport

4.1.4.1 *Metals*

Metals may be encountered in their singular elemental states but are more commonly found as complexes. Arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc all exist in a variety of oxidative states depending on element loading, microbial activity, nutrient content, pH, redox potential, suspended sediment load, sedimentation rate, salinity, and other variables (Eisler 1987a). When found as compounds, metals are typically bound to other elements, including carbon, oxygen, chlorine, and sulfur atoms. In estuarine environments, metal compounds that include chlorine are regularly encountered. In water, some metals form soluble compounds, while others will precipitate out of solution as insoluble salts; these reactions are largely dependent on water chemistry. Barium and lead are typically insoluble in water, while silver and zinc are usually found in soluble forms. Metals are also often bound to sediments due to bonding with suspended solids or organic matter in water or due to reactions on the surface of clay minerals.

Some metals are considered essential nutrients in plants and animals and uptake may be regulated as such (ATSDR 2004). Plants' tolerance to, and ability to accumulate metals, varies widely by chemical, species, and environmental conditions. Similarly for non-plant aquatic species, the uptake of metals into tissues is highly variable. Some metals are lipophilic (mercury and lead), and concentrations tend to accumulate in fat, liver, brain, egg, and other tissues. Other metals, such as zinc, behave differently with concentrations in organisms not directly related to the concentration in the environment (McGeer et al. 2003). The evidence suggests that fish placed in environments with lower zinc concentrations can sequester zinc in their bodies. The fact that many organisms are capable of regulating internal metals concentrations within certain limits means that, in some instances, organisms can stabilize internal concentrations against perturbations or high concentrations in the external environment (World Health Organization [WHO] 2001).

4.1.4.2 *PAHs*

PAHs are a large group of chlorinated organic chemicals composed of two or more fused benzene rings (USEPA 2003b). PAHs in the environment originate primarily from two sources: petrogenic (i.e., petroleum sources, including different types of oils, coal, and organic shales) and pyrogenic (i.e., combustion), with the majority associated with pyrogenic sources. Petrogenic PAHs are usually associated with local or point sources such as refineries and other petroleum industries, while pyrogenic PAHs tend to occur on a broader scale.

PAHs are considered persistent organic pollutants, but may undergo a variety of degradation processes in abiotic environmental media, including volatilization, photolysis, oxidation, biodegradation, and binding to solid media. The rate by which PAHs volatilize from the water column to the atmosphere is dependent on Henry's law constant for the particular PAHs present. Low-molecular-weight (LMW) PAHs volatilize more readily than high-molecular-weight (HMW) PAHs. Photolysis of PAHs has been shown to be dependent on the physical and chemical structure of the substrate the PAH is sorbed to as opposed to the structure of the PAH itself (ATSDR 1995). Similarly, the rate of oxidation is influenced by the nature of the media, as well as PAH structure. Biodegradation of PAHs is influenced by concentration, DO, water temperature, and organisms present (ATSDR 1995). Binding of PAHs to organic carbon is controlled by the organic carbon-water partitioning coefficient (K_{oc}). Degradation of PAHs in water depends in part on the temperature and oxygen content of the water (ATSDR 1995). Degradation in soils and sediments depends in part on soil organic content, soil structure, physical factors, the presence of microbes, and the characteristics of the microbes and PAHs (ATSDR 1995).

Physio-chemical properties that affect the fate of individual PAH compounds depend in part on the molecular weight and ring structure of the individual PAH. In general, PAHs have low water solubility and a high K_{oc} value that indicate moderate to high affinity for organic carbon (ATSDR 1995). Thus, in aquatic systems, most of the total amount of PAHs is typically sorbed to suspended particulate matter or sediments rather than being found in the dissolved phase (ATSDR 1995).

Photo-oxidation and chemical oxidation are important degradation processes for PAHs in water (ATSDR 1995). PAHs can also be chemically oxidized by chlorination and ozonation. Photolysis, hydrolysis, and chemical oxidation are generally not considered important degradation processes for PAHs in soils and sediments, especially for HMW PAHs (ATSDR 1995). Data suggest that naphthalene and phenanthrene may biodegrade most readily in water; anthracene, benzo(a)anthracene, chrysene, and fluorene may biodegrade in sediment water/slurries; and benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, and other PAHs with five or more rings may not biodegrade readily at all (ATSDR 1995).

PAHs are lipophilic and can rapidly bioaccumulate from water, sediments, soil, and food. Less soluble PAHs are typically taken up more readily in the gastrointestinal tracts of animals (USEPA 2007). In general, bioconcentration is higher for HMW than LMW PAHs, but can vary by taxa based on the ability of organisms to metabolize parent PAHs to other compounds (ATSDR 1995). Fish can metabolize PAHs in the liver and excrete the metabolites in feces and urine. Most crustaceans also possess the required enzymes for metabolism. Organisms tend to take up PAHs easily from food, although dietary exposure sometimes contributes a limited amount to body burdens compared to water exposure. Due to metabolic ability, PAH concentrations in fish are typically low. Some data suggest that skin, as well as lipids, may be a temporary site of accumulation and may pose a barrier to the migration of PAHs in tissues. Mollusks and some other invertebrates may be unable to metabolize PAHs efficiently, although they can eliminate them. Studies of marine mollusks have found that while LMW PAHs were bioconcentrated more or less than HMW PAHs, the LMW PAHs were more readily eliminated. Sediment can also be a significant source of body burdens of PAHs for benthic invertebrates and fish. Biomagnification through aquatic food chains has not been observed, likely due to rapid biotransformation and elimination (ATSDR 1995; Eisler 1987b).

4.1.4.3 *PCBs*

PCBs are a group of chemicals that were produced between 1929 and 1978 in the United States for use as industrial coolants, insulators, and lubricants. The term PCBs encompasses 209 individual congeners with one to 10 chlorine atoms attached to a biphenyl molecule. PCBs may be grouped by homologues (defined by the number of chlorines), Aroclors (trade names), coplanar/non-coplanar (positions of chlorines), and as total PCBs (i.e., sum of homologues, sum of Aroclors, or sum of congeners). PCBs are highly lipophilic, semivolatile compounds that bioaccumulate and biomagnify in ecological receptors (USEPA 1999).

Release of PCBs to the environment occurred as the result of industrial discharges, leaks, disposal, landfills, and atmospheric transport of incompletely incinerated PCBs (Eisler 1986). The same chemical properties that made PCBs useful to industry are now responsible for persistent levels of PCBs remaining in the environment. Although the manufacture and use of PCBs was banned in the United States in 1979, they are a ubiquitous contaminant worldwide. This is because PCBs are extremely stable and slow to degrade (Eisler 1986). PCBs are generally ubiquitous in the aquatic environment, particularly in sediments. They may enter aquatic systems from wet and dry deposition, river inflows, groundwater flow, and direct and indirect discharge from industrial facilities. Once in aquatic systems, PCBs quickly partition into the more nonpolar compartments of the ecosystem or are physically adsorbed on particulate matter (Eisler 1986). PCBs are relatively insoluble in water, but are freely soluble in nonpolar organic solvents and in biological lipids (Eisler 1986).

Physical properties of each PCB molecule affect what happens to it over time in the environment. Increasing chlorination causes the solubility of PCBs to decrease and also affects the degree to which a PCB sorbs to organic matter and the ability of biota to excrete the PCB rather than retain it in body tissues. As a result, individual PCB congeners have the potential to bioaccumulate to different extents.

PCB mixtures in environmental media degrade over time, either by processes of weathering or by microbial degradation. These processes can cause dechlorination of PCB molecules, thus affecting the overall bioavailability of individual PCBs. The degree of dechlorination depends on the number and position of chlorine atoms, with lower chlorinated compounds more readily degraded. The degree of chlorination also leads to a wide range of volatility among congeners (Wenning et al. 2011).

PCB molecules are hydrophobic (have low solubility in water), adhere readily to organic matter in soil or sediment, and may bioaccumulate in adipose tissue in fish or other animals. Thus, the highest levels of exposure to PCBs in the environment typically occur through the food chain via ingestion of food items, rather than by direct contact with soil, sediment, air, or water. Many physical, chemical, and biological processes can affect the bioavailability and subsequent uptake of PCBs in the environment, including organic carbon content in sediment or soil and the lipid content in the receptor species. Accumulations are highest in adipose tissue and skin. Accumulation and metabolism are a function of chlorination, with higher chlorinated compounds more difficult to metabolize and more likely to accumulate (Eisler 1986).

4.1.4.4 *Organochlorine Pesticides*

The organochlorine compounds chlordane and DDT are persistent hydrocarbon compounds that were widely used as pesticides in the recent past. Both chlordane and DDT are synthesized chemicals, and their presence in the environment is associated with their production and use as pesticides. These compounds became widely used in agriculture beginning in the 1940s and 1950s. DDT usage in the United States was banned in 1972, while chlordane was banned in 1988 due to increasing evidence regarding their environmental persistence and potential adverse effects on wildlife and human health. Organochlorine pesticides can enter the environment after pesticide applications, disposal of contaminated wastes into landfills, and releases from manufacturing plants.

In general, the organochlorine pesticides have low aqueous solubility and tend to bind strongly to particulates and organic matter in soils and sediments. Chlordane and DDT are very persistent with half lives up to 30 years depending on environmental conditions. It is not known whether much breakdown of chlordane occurs in water or in sediment. Chlordane breaks down in the atmosphere by reacting with light and with some chemicals in the atmosphere; however, it is sufficiently long lived that it can travel long distances and be deposited on land or in water far from its source. Similarly, DDT is highly persistent, but does break down slowly via photolysis and both aerobic and anaerobic degradation. Both chlordane and DDT, and their metabolites, are lipophilic and readily taken up into the aquatic food chain. These chemicals are also known to biomagnify in higher trophic level organisms.

Organochlorine pesticides are highly bioaccumulative, a primary reason they were effective as pesticides. DDT and chlordane bioconcentrate in organisms making up the lower trophic levels of the food chain and accumulate moving up the food chain. Following introduction via the gills or through ingestion of prey items, organochlorines travel through the blood and are then distributed to soft organs and ultimately lipids (USEPA 1999). The individual forms of chlordane vary in their uptake and bioaccumulation (Eisler 1990). After accumulation in tissues, organochlorines may be eliminated over time if exposure is terminated. Little is known about the uptake of DDT and chlordane into aquatic plants.

4.1.4.5 *Dioxins and Furans*

Dioxins and furans are aromatic heterocyclic compounds in the organochlorine group. Dioxins and furans are similar in structure to PCBs with the main difference being the addition of one oxygen atom between rings in furans and two oxygen atoms between rings of the dioxin molecules. Dioxins and furans have no commercial uses and have been introduced to the environment as byproducts of industrial processes and both natural and anthropogenic combustion. The number of chlorine atoms included in the molecular structure is variable between one and eight resulting in 75 possible dioxin isomers and 135 possible furan isomers. Toxicity of these chemicals is variable based on the position of the chlorine atoms, especially in the “lateral positions” (2,3,7, and 8) with 2,3,7,8-TCDD and 2,3,7,8- tetrachlorodibenzofuran (2,3,7,8-TCDF) having chlorine in all four positions and, as a result, are the most toxic isomers (Hoffman et al.

1995). A group of 12 PCBs are referred to as “dioxin-like compounds” as they behave similarly to dioxin (USEPA 2006a).

Dioxins and furans are commonly detected in air, soil, and sediment around the world. Dioxins and furans are widely distributed at low concentrations with higher concentrations noted in heavily industrialized areas. These compounds enter aquatic environments via soil erosion and stormwater runoff in urban areas and break down very slowly. Like other chlorinated chemicals, dioxins and furans are persistent environmental pollutants ending up in sediments in the aquatic environment due to poor solubility. Increased chlorination of isomers leads to an increase in overall stability and lipophilicity, as well as the slowing of elimination in organisms (USEPA 2008b). Photolysis and volatilization may remove some dioxins and furans from the aquatic environment, but these effects decrease with depth leaving sediments generally unaffected depending on water clarity.

Dioxins and furans are readily taken up into the aquatic food chain; depending on the chemical structure these constituents are known to biomagnify in higher trophic-level organisms in aquatic ecosystems (Hoffman et al. 1995).They are readily biomagnified in the aquatic food chain, moving from sediments to higher trophic-level organisms. The individual molecular structure of the isomer determines the exact uptake and bioaccumulation due to chemical properties and individual K_{ow} values. After accumulation in tissues, dioxins and furans are not readily eliminated by the organism.

4.1.4.6 *Bis(2-ethylhexyl)phthalate*

Bis(2-ethylhexyl)phthalate (also commonly known as BEHP, di[2-ethylhexyl]phthalate, and DEHP) is the most common phthalate compound and is widely used as a softener in the manufacturing of products made of polyvinyl chloride. Products include packaging film and sheets, wall coverings, floor tiles, upholstery, shower curtains, garden hoses, swimming pool liners, rainwear, shoes, medical tubing, and sheathing for wire and cable (Office of Environmental Health Hazard Agency [OEHHA] 2009). BEHP is ubiquitous in the environment due to the high usage levels in modern society. BEHP can leach out of common products and enter the environment.

In landfills, BEHP has been shown to leach out of products and may enter runoff surface water or groundwater. Once in the water, BEHP has low solubility and tends to move slowly. In aquatic systems, BEHP is generally found attached to suspended particles or in the sediment. BEHP is readily degraded with exposure to light. The dominant mechanism for degradation in surface water and sediment is via exposure to bacteria and actinomycetes (OEHHA 2009). Half-lives in surface and marine waters range from under 1 day to more than 2 weeks (OEHHA 2009). BEHP is not considered a persistent pollutant.

BEHP has been shown to bioaccumulate in aquatic plants and invertebrates (OEHHA 2009). Although BEHP is often found in lipid tissues, fish do not readily bioaccumulate BEHP (OEHHA 2009). Specific enzymes in the gills of freshwater fish are thought to be able to break down BEHP, limiting entry into the organism, and thus, limiting bioaccumulation (OEHHA 2009).

4.1.5 Ecotoxicity of COPECs

4.1.5.1 *Metals*

The toxicity of metals in the aquatic environment is dependent on the partitioning and speciation of the given contaminant in the environment, which affect the overall bioavailability of the metal. Examining the total concentration of metal in a medium is not always predictive of the bioavailability of the metal in that environment. In general, metal bioavailability is dependent on redox, pH, hardness, organic carbon, percent fines, AVS, and other factors (ATSDR 2004; Eisler 1998; Hoffman et al. 1995). For several divalent metals, a key partitioning phase that controls cationic metal activity and toxicity in sediments appears to be AVS, which is a measure of the amount of sulfides in sediment capable of binding to metals (DiToro et al. 1990, 1991; Ankley et al. 1996). Examining SEM and AVS can successfully estimate the bioavailability of some metals in aquatic environments.

Some metals can act as essential nutrients to plants (e.g., copper, nickel, zinc, and others), while others can adversely affect growth and photosynthesis and may cause lethality depending on the chemical and species present (ATSDR 2004). In invertebrates, exposure to metals can cause variable effects based on the taxa. Effects due to metals exposure to invertebrates may include decreased reproduction, immobility, gill damage, reduced filtration and feeding rates, and valve closure. In fish, effects from exposure to metals can include alterations to respiration and osmoregulation, gill damage, changes in olfactory and lateral line function, and changes to reproductive and developmental success and behavior (ATSDR 2004, 2005; Eisler 1987a, 1998). Some species may be able to develop tolerances to certain metals, including but not limited to, cadmium and copper, via binding metals to metallothioneins and other proteins as a protective mechanism (Hoffman et al. 1995; International Program on Chemical Safety [IPCS] 1992).

4.1.5.2 *PAHs*

The aquatic toxicity of PAHs may be mitigated by several factors: PAH concentrations in even heavily polluted water are usually far below levels required for acute toxic effects, and PAHs in sediment may be less bioavailable and less toxic than PAHs in solution (Eisler 1987b). The molecular weight of PAHs is also an important factor in aquatic toxicity because toxicity generally increases as molecular weight increases; however, HMW PAHs tend to have low acute toxicity, possibly due to low water solubility (Eisler 1987b). Among aquatic organisms, crustaceans are most sensitive and teleost fish are least sensitive (Eisler 1987b). Toxic effects of PAH exposure in various taxa may include effects on photosynthesis, mobility, blood chemistry, skin, hematopoietic system, organs, immune system, respiratory and cardiovascular systems, reproduction, growth, and survival (Eisler 1987b; USEPA 2007).

Unsubstituted LMW PAHs are not generally carcinogenic, while many HMW PAHs are known or suspected carcinogens, genotoxins, and mutagens (Eisler 1987b). Neoplasms or related disorders have been observed in connection with high exposure to HMW PAHs in terrestrial and aquatic organisms, including invertebrates and fish. Intraspecies and interspecies differences in response, as well as significant interactions between HMW PAHs of differing potential carcinogenicity, make characterization of the specific carcinogenic contribution of individual HMW PAHs in the field difficult (Eisler 1987b). HMW PAHs in sediment have been associated with effects on benthic invertebrates, including reproductive effects, delayed emergence, sediment avoidance, and mortality. The prevalent mechanism of toxicity in invertebrates is narcosis, which can result in the alteration of cell membrane function (Burgess 2009). A variety of carcinogenic (especially in the liver), teratogenic, and other developmental effects have been observed in fish in connection with HMW PAH exposure in water and sediment (Hoffman et al. 1995; Burgess 2009).

4.1.5.3 *PCBs*

Coplanar PCBs have chlorine atoms in non-ortho positions that allow the two benzene rings to lie in the same plane; non-coplanar PCBs have chlorine atoms in the ortho position causing the molecule to twist and the rings are on different planes. The relative toxicities of coplanar PCBs are calculated by expressing their toxicity in relation to 2,3,7,8-TCDD, which also shares the coplanar structure and is the most toxic dioxin (Eisler and Belisle 1996). These fractional potencies are known as toxic equivalency factors (TEFs) and are useful in estimating toxicity in PCBs and PCB mixtures. Toxicity of PCBs is a factor of both the number of chlorine atoms in the molecule and how close the benzene rings are to being coplanar (Loseto and Ross 2011).

PCB toxicity varies among different species of animals, but in general, reproductive effects tend to be the most sensitive endpoint. PCBs may also act as endocrine disruptors. Toxicity is believed to be related to the ability of the congeners to induce cytochrome P450-dependent activity. There are limited data regarding toxicity of PCBs to plant species. PCBs incorporated into phytoplankton exert inhibitory effects on photosynthesis and cell motility (Eisler 1986). PCB toxicity to invertebrates is generally less than that observed in vertebrate species due to limited detoxification systems. Crustaceans and younger developmental stages appear to be the most sensitive groups, and lower chlorinated compounds appeared to be more toxic. The ability of invertebrates to accumulate PCBs from sediment or the water column makes them good indicator species.

PCB effects may be associated with the survival, growth, and reproduction of individuals within the local populations of fish and wildlife species, with reproduction broadly defined to include egg maturation, spawning, egg hatchability, and survival of fish larvae. The most sensitive endpoint for effects of PCB on fish is found during early life stage survival and recruitment as a result of PCB transfer from maternal tissue to eggs (Berlin et al. 1981). As a group, birds are more resistant to acutely toxic effects of PCBs than mammals, based on literature values (Eisler 1986). Signs of PCB poisoning among birds included morbidity, tremors, beak pointed upwards, and muscular incoordination (Eisler 1986).

4.1.5.4 *Organochlorine Pesticides*

Organochlorine pesticides are made up of four groups based on chemical structure; these groups include the cyclodienes (e.g., chlordane, endosulfan, and endrin), diphenyl aliphatics (e.g., DDT and its metabolites), hexachlorocyclohexanes (e.g., lindane), and polychloroterpenes (e.g., toxaphene) (Becvar and Lotufo 2011). As a group, the cylcodienes are characterized as the most acutely toxic of the organochlorine pesticides (Elliott and Bishop 2011). There is variation in toxicity between the compounds, likely because of their varying ability to be metabolized. For example, chlordane can be metabolized to form a number of different metabolic products, including heptachlor and heptachlor epoxide, which may be more toxic than chlordane itself. However, all cyclodienes act through a central nervous system mechanism, with dietary exposure considered the most important route (Elliott and Bishop 2011). Acute toxicity of organochlorine pesticides to aquatic organisms has long been studied, oftentimes with rapid death of sensitive organisms at relatively low tissue concentrations and the accumulation of higher residues in the remaining resistant organisms (Becvar and Lotufo 2011). At low concentrations, pink shrimp are similarly susceptible to chlordane as grass shrimp. In contrast, similarly exposed Eastern oysters only showed decreased growth, with no apparent effects on mortality. Signs of chlordane poisoning in fish included hyper excitability, increased respiration rate, erratic swimming, loss of equilibrium, and convulsions; death frequently occurred within 12 hours of exposure (NRCC 1975).

The diphenyl aliphatics, such as DDT, are highly toxic to aquatic invertebrates with early developmental stages, which make them more susceptible to acute effects of DDT than adults (WHO 1989). Some effects may be reversible prior to lethality setting in, and some invertebrates have also shown resistance to DDT (WHO 1989). DDT is highly toxic to fish, causing effects to behavior, biochemistry, development, growth, histology, reproduction, and mortality (WHO 1989).

4.1.5.5 *Dioxins and Furans*

While over 200 dioxin and furan isomers exist, seven dioxins and 10 furans are known by the WHO to be highly toxic (USEPA 2008b), with the most toxic isomers being 2,3,7,8-TCDD and 2,3,7,8-TCDF. In order to more readily assess the toxicity of dioxins and furans as a mixture, the system of TEFs was developed based on the toxicity of 2,3,7,8-TCDD. In this system, each isomer on the WHO list is assigned a factor (i.e., TEF) based on its potency relative to 2,3,7,8-TCDD; the estimated toxicity of all isomers present is summed to come up with an overall estimate of toxicity. Toxicity for these compounds is thought to be broken into three modes of action: 1) irreversible chemical binding to macromolecules inhibiting their function, 2) accumulation to high concentrations in lipids resulting in stress-induced dosing, and 3) irreversible binding to cellular receptors and enzymes inhibiting biochemical communications between cells (McKinney and Walker 1994). In most cases, the toxicity of dioxins and furans is linked to the interruption of function of a specific intracellular protein (AhR) (USEPA 2004).

Invertebrate and vertebrate organisms respond differently to elevated concentrations of dioxins and furans, with invertebrates being relatively tolerant of exposure compared to vertebrate species. This difference may be due to the absence of some receptors in invertebrates that are adversely affected in vertebrate species (Hoffman et al. 1995). Due to their tolerance to exposure, invertebrates may accumulate dioxins and furans into their tissues from sediments, making them more biologically available to vertebrate species in the aquatic environment (Hoffman et al. 1995).

Laboratory toxicity data show that fish are generally more sensitive to 2,3,7,8-TCDD than plants, aquatic invertebrates, and other aquatic vertebrates (e.g., amphibians) (USEPA 2008b). The high lipid content in fish makes them highly susceptible to bioaccumulation of 2,3,7,8-TCDD in their tissues, which can essentially be transferred up the food chain to higher-trophic-level organisms, such as birds and mammals (including humans). Effects of 2,3,7,8-TCDD exposure to mammals and birds are similar to fish and include delayed mortality, a “wasting” syndrome characterized by reduced food intake and reduced body weight, reproductive toxicity, histopathological alterations, developmental abnormalities, and immunosupression (USEPA 2008b).

4.1.5.6 *BEHP*

Toxicity to aquatic organisms is variable with arthropods being the most sensitive group that have been studied. Some fish, including the medaka, were sensitive to exposure with sublethal effects noted at low exposure concentrations (OEHHA 2009). However, in most studies toxic effects did not occur until reaching an exposure level above the water solubility of BEHP (OEHHA 2009). Sublethal effects include increased hatching time, reductions in body weight, reduced gonado-somatic index (GSI), changes in blood chemistry, developmental difficulty, and changes in sex ratio. Lethality is also possible depending on the concentration and organism (OEHHA 2009).

4.2 Ecological Conceptual Site Model

A preliminary ecological CSM was presented in the Phase I RIWP (Tierra 2005), in the SLERA (USEPA 2008a), and was recently updated in the Draft Interim Conceptual Site Model Report (Tierra 2011). Based on the review of additional data and reports (i.e., the data and information summarized in this document) and decisions from the BHHERA Workshop (ARCADIS and ToxStrategies 2011), the ecological/food web components of the CSM have been updated as displayed on Figure 4-1; the specific ecological exposure pathways are depicted on Figure 4-2. A summary of the key, risk-based components of the CSM is provided below.

4.3 Ecological Exposure Pathways and Receptors

Representative receptor species for evaluation in the BERA were selected based on the available reports, biological surveys, habitat data, and other information from the NBSA, as discussed above. The following factors that were considered for the selection of proposed ecological receptors are the same as those considered in the Problem Formulation Document for the LPRRP (Windward/AECOM 2009):

- **Potential for exposure to sediment-associated chemicals** – Ecological species exposed to sediments through direct and incidental ingestion of sediment, ingestion of sediment-exposed prey, or direct contact with sediments have the greatest potential for exposure to sediment-associated chemicals. In addition, ecological species with small home ranges and whose site use is limited to the NBSA have a greater potential for exposure to site-related chemicals in sediment than do migratory species, species with large home ranges, or species that do not exclusively use aquatic habitats.

- **Relative ability to bioaccumulate/biomagnify site-related chemicals** – Species from upper trophic levels (e.g., piscivores) have a greater potential for long-term exposure to bioaccumulative chemicals and a greater potential for the biomagnification of those chemicals.

- **Societal and cultural significance (including species that are highly valued by society)** – Federally and state-listed threatened and endangered species have special consideration in the selection of receptors. Appendix A provides the animal and plant species listed by the states of New Jersey and New York. Also, those species that are commercially and recreationally important receive greater consideration in the selection of receptors.

- **Ecological significance (including species that serve a unique ecological function)** – Species with unique foraging preferences, such as those that primarily feed in shallow mudflat areas or are bottom-dwellers, receive special consideration.

- **Sensitivity to site-related chemicals** – Species with known sensitivities to particular chemicals (e.g., piscivorous birds sensitive to DDT) receive special consideration in the selection of receptors.

Ecological receptors may be directly exposed to chemicals through contact (e.g., direct contact to sediment and/or surface water), through ingestion (or inhalation) of chemicals in water or sediments, or indirectly through the ingestion of contaminated food items. For an exposure pathway to be complete, a chemical must be able to travel from the source to receptors that utilize or inhabit the site and be taken up by the receptors via one or more exposure routes.

The representative receptors that may be exposed to chemical constituents in sediment, surface water, and/or tissue from the NBSA are listed below. Most of these organisms are subject to being exposed to multiple geomorphic and geographic areas within the NBSA. Aside from plants and infaunal benthic invertebrates, most species are not sessile and will actively move in and out of both geographic and geomorphic areas; thus exposing them to a wide range of chemical constituents within Newark Bay sediments and surface water.

- Aquatic plants
- Invertebrates
  - Benthic infauna (e.g., amphipods [*Ampelisca abdita* and *Leptocheirus plumulosus*], polychaetes [*Neanthes virens*])
  - Epibenthic (e.g., crustaceans [blue crab and shrimp], mollusks [eastern oyster, softshell clam, blue mussel, *Macoma* sp.], echinoderms [sea stars and sea urchins])
  - Pelagic (e.g., zooplankton)
- Fish
  - Forage (e.g., mummichog, bay anchovy, alewife, and herring)
  - Benthic demersal (e.g., Atlantic tomcod, winter/summer flounder, and Atlantic sturgeon)
  - Pelagic predatory (e.g., white perch, striped bass, American eel, weakfish, and bluefish)
- Birds
  - Benthivorous (e.g., spotted sandpiper)
  - Carnivorous (e.g., peregrine falcon)
  - Insectivorous (e.g., tree swallow, marsh wren, and red-winged blackbird)

- Omnivorous (e.g., lesser scaup)

- Piscivorous (e.g., double-crested cormorant, osprey, common tern, and belted kingfisher)

- Mammals

  - Insectivorous (e.g., little brown bat)

  - Omnivorous (e.g., raccoon and muskrat)

  - Piscivorous (e.g., river otter and harbor seal)

4.4 Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints

AEs are defined as “an explicit expression of the environmental value that is to be protected” (USEPA 1997). Because it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem, AEs focus the risk assessment on particular components of the ecosystem that could be adversely affected by site-related constituents. The five selected AEs are as follows:

- Survival and growth of aquatic plants as a food resource and habitat for fish and wildlife

- Survival, growth, and reproduction of invertebrates

- Survival, growth, and reproduction of fish

- Survival, growth, and reproduction of birds

- Survival, growth, and reproduction of mammals

Following the selection of AEs, testable hypotheses are developed to determine whether or not a potential risk to the AE exists (USEPA 1997). A testable hypothesis is an operational statement of an investigator’s research assumption made to evaluate logical or empirical consequences (USEPA 1997, 1998). Similar to the LPRRP, the testable hypotheses for the NBSA are presented as a series of risk questions about the relationship between each of the AEs and the responses of the receptors when exposed to chemicals within Newark Bay.

Hypotheses usually postulate that there is no effect or no difference (among groups or measurements), and data are collected to confirm or refute that hypothesis. This document provides a series of risk questions developed based on the June 2011 BHHERA workshop (ARCADIS and ToxStrategies 2011). Table 4-3 presents an overview of the proposed AEs, testable risk hypotheses (phrased as questions), representative receptors, MEs, data use objectives, and biological data to be collected to support the BERA. Also included in Table 4-3 is a general discussion of the data that may be collected and/or compiled based on existing data, as appropriate, from urban background areas to help address the risk questions and MEs. An urban regional background approach and stressor evaluation will be developed for use in the risk characterization of the risk assessments, subject to USEPA approval (USEPA 2002).

An ME is defined as the “measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint” (USEPA 1997). Although final MEs will not be selected until Step 4 of the ERA process (i.e., during the preparation of work plans/sampling plans), potential MEs are described and discussed under each testable risk question below.

4.4.1 Plants

Assessment Endpoint 1: Survival and growth of aquatic plants as a food resource and habitat for fish and wildlife.

Testable Hypothesis (i.e., risk question): *Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival and growth of aquatic plants?*

> This question will be addressed by comparing sediment and surface water chemical concentrations collected from relevant exposure areas with available and relevant toxicity-based screening benchmarks (i.e., aquatic thresholds). The data use objective for this ME is to estimate the exposure of plants via direct contact and uptake of chemicals in surface water and sediment. Surface water and surficial sediment from relevant exposure areas will be analyzed for chemical and physical parameters.

4.4.2 Invertebrates

Assessment Endpoint 2: Survival, growth, and reproduction of invertebrates.

Testable Hypothesis (i.e., risk question): *Are invertebrate communities in the NBSA different from those found in similar nearby water bodies with chemical concentrations at regional background levels?*

This question will be addressed by comparing community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) from Newark Bay to appropriate urban regional background datasets using diversity indices, multivariate, and spatial statistical techniques. The data (chemicals and conventional parameters, such as grain size) and results of the benthic community analysis will be used to develop benthic community metrics to be used as an additional line of evidence. This line of evidence will be part of the sediment quality triad (SQT) approach, which is a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics. Additional information will be collected on ecosystem characteristics, such as grain size, TOC, and other attributes, to assist in the evaluation of the data in the context of the overall health of the benthic community. The details of the approach for the SQT and risk characterization using the benthic community data will be presented in the Risk Analysis and Risk Characterization Work Plan.

Testable Hypothesis (i.e., risk question): *Are COPEC residues in invertebrate tissues from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of invertebrates?*

This question will be addressed by comparing chemical concentrations in laboratory-exposed and/or site-collected invertebrate tissues to literature-based CBR values. The data use objective for this ME is to assess the adverse effects of chemicals on the invertebrate community and to use this information to develop a food web model for upper trophic-level organisms. A polychaete worm (e.g., *Nereis virens*) and the eastern oyster (*Crassostrea virginica*) may be used to conduct the 28-day laboratory and/or field bioaccumulation tests. Whole-body benthic infaunal invertebrate tissue from the tests will be chemically analyzed and then compared to literature-based CBRs. In addition, tissue data from softshell clam and/or blue crab will be analyzed and compared to literature-based CBRs.

Testable Hypothesis (i.e., risk question): *Are COPEC concentrations in NBSA sediments from the BAZ at levels that might cause an adverse effect on survival, growth, and/or reproduction of the invertebrate community?*

This question will be addressed with two MEs. Chemical concentrations in sediment will be compared to toxicity-based sediment benchmarks from the literature. The data use objective for this ME is to evaluate the effects of chemical concentrations in sediment on the benthic invertebrate community of the NBSA. Surficial sediment will be collected from the BAZ, which is estimated to be the top 6 inches, and chemically analyzed.

Laboratory toxicity tests using NBSA surface sediment will be conducted. Proposed tests include a 10-day survival and growth study with *Ampelisca abdita*, a subset of stations are proposed for a 28-day study with *Leptocheirus plumulosus* for survival, growth, and reproduction; and a caged in-situ study with eastern oyster for reproduction. The data use objective for this ME is to assess the adverse effects of chemicals (and evaluation of conventional parameters, such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community.

Surface sediment for the bioassays will be collected throughout the NBSA from the BAZ, which is estimated to be the top 6 inches. The results of the bioassays will be statistically compared to bioassays conducted with control sediment. The results will also be evaluated using existing urban regional background comparisons to support risk management decisions, subject to USEPA approval of an urban regional background approach. Amphipods are considered to be a sensitive biological organism for representing potential risk to the benthic community.

Testable Hypothesis (i.e., risk question): *Are COPEC concentrations in pore water and surface water from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of invertebrates?*

This question will be addressed comparing dissolved chemical concentrations in pore and surface water collected from benthic invertebrate exposure areas to toxicity-based values (i.e., aquatic thresholds). The data use objective for this ME is to estimate the exposure of the benthic invertebrate community via the surface water exposure pathway to chemicals in surface water at two distinct depth intervals.

4.4.3 Fish

Assessment Endpoint 3: Survival, growth, and reproduction of fish.

Testable Hypothesis (i.e., risk question): *Are COPEC concentrations in fish tissue from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish that use the NBSA?*

Identified fish receptors will be collected throughout the NBSA for whole-body chemical analyses. These data will be compared to literature-based CBRs and/or to whole-body fish tissue chemical concentrations of selected receptors from background locations. Specific species of fish will be targeted so that representative species from each of three trophic levels are captured: forage fish, benthic/demersal, and pelagic predatory. Additional physical and biological information will be collected (details to be provided in the upcoming Quality Assurance Project Plans [QAPPs]) to assist in the interpretation of results in terms of fish population health. Chemical concentrations in a subset of liver tissues will also be collected and compared to tissue-residues for liver.

External health observations (gross histological analysis) will be made on all fish to provide information on fish population health. The qualitative fish health observation data (e.g., gross histology) will be used to provide general information about the health of NBSA fish populations. Internal histopathology (e.g., of existing tumors and in-liver and gonad tissues) of a subset (e.g., 5 to 10 select fish) will also be conducted.

Testable Hypothesis (i.e., risk question): *Are COPEC concentrations in pore water, surface water, and sediment from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish?*

Chemical concentrations in dissolved pore water and surface water collected from the NBSA will be compared to toxicity-based values (i.e., aquatic thresholds). The data use objective for this ME is to estimate the exposure of fish via the surface water exposure pathway to chemicals in surface water. Surface water data, including chemical and physical parameters, such as DO, salinity, pH, and hardness, will be used to address this risk question.

Chemical concentrations in sediment will be compared to toxicity-based sediment benchmarks from the literature. The data use objective for this ME is to evaluate the effects of chemical concentrations in sediment on fish populations in the NBSA. Surface sediment will be collected from the BAZ, which is estimated to be the top 6 inches, chemically analyzed, and compared to appropriate benchmarks.

To evaluate the potential effects of chemical constituents on reproduction of NBSA fish, a study may be conducted to assess the reproduction of fish species common in the NBSA, such as white perch or mummichog, similar to studies conducted by Cooper and Buchanan (2007). Fish would be collected from both the NBSA and a reference location. Reproductive health will be assessed on individual fish collected via morphology and/or biomarkers (e.g., GSI, gonad condition and fecundity estimates, and vitellogenin) (Cooper and Buchanan 2007; Hsiao et al. 1994). Laboratory reproductive bioassays may also be conducted on the mummichog using sediment and/or water collected from various locations in the NBSA, as well as a reference area. Methods for a short-term reproductive bioassay with mummichog have been presented by Peters et al. (2007).

Assessing reproductive health of fish species in a large area can be difficult as effects seen in an individual fish may not always correspond to population-level effects. Some species have also been shown to develop adaptive resistance to environmental contamination over time (Cooper and Buchanan 2007; Nacci et al. 1999). It is recommended to use multiple lines of evidence (e.g., community studies, reproductive health of individuals, and bioassays) to estimate overall reproductive health in fish populations in the NBSA.

4.4.4 Birds

Assessment Endpoint 4: Survival, growth, and reproduction of birds.

Testable Hypothesis (i.e., risk question): *Are modeled dietary doses of COPECs based on NBSA biota, sediment, and surface water at levels that might cause an adverse effect on survival, growth, and/or reproduction of birds that use the NBSA?*

This ME will be evaluated by comparing receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue with literature-based dietary dose toxicity reference values (TRVs). The data use objective for this ME is to estimate exposure of bird receptors via various exposure pathways to chemicals in surface water, sediment, and prey tissue. Five different feeding guilds will be evaluated: piscivorous, benthivorous/sediment-probing, omnivorous, insectivorous, and carnivorous. Surface sediment chemical data (from the BAZ), surface water chemical data, and benthic invertebrate and/or fish prey tissue chemical data, depending on receptor-specific diet, will be used to develop the dietary model for each bird receptor. Exposure data used in this ME will be used in the development of a food web model.

Risks to birds may also be assessed by evaluating field-collected tissue residues of birds (specifically egg tissue) that will be compared to literature-based CBRs for avian eggs. However, there are limited toxicity thresholds for bird tissues, and there are permitting limitations associated with collecting these data in the field.

4.4.5 Mammals

Assessment Endpoint 5: Survival, growth, and reproduction of mammals.

Testable Hypothesis (i.e., risk question): *Are modeled dietary doses of COPECs based on NBSA biota, sediment, and surface water at levels that might cause an adverse effect on survival, growth, and/or reproduction of aquatic and semi-aquatic mammals that use the NBSA?*

This ME will be evaluated by comparing receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue with literature-based dietary dose TRVs. The data use objective for this ME is to estimate exposure of aquatic and semi-aquatic mammals to chemicals in NBSA surface water, sediment, and prey tissue. Three different feeding guilds will be evaluated: omnivorous, piscivorous, and insectivorous. Surface sediment chemical data (from the BAZ), surface water chemical data, and benthic invertebrate and/or fish prey tissue chemical data, depending on receptor-specific diet, will be used to develop the dietary model for each mammal receptor. Exposure data used in this ME will be used in the development of a food web model.

4.5 Ecological Risk Assessment Data Needs

Data needs for the BERA are identified in Table 4-3, as well as with their associated data use objective and include the following general sampling needs:

- Co-located surficial sediment (i.e., top 6 inches) and pore water analytical data from throughout Newark Bay, including the Intertidal Areas, Subtidal Flats, and Channels

- Surface water analytical data from two distinct depths

- Forage fish, benthic fish, and pelagic predatory fish

- Whole body invertebrates (e.g., blue crab and softshell clam)

- Benthic community data

- Egg, feather, or blood tissue from birds

- Mammal population survey

5. Baseline Human Health Risk Assessment

This section discusses the BHHRA framework for the NBSA. The human health CSM, including potential exposure scenarios, populations exposed, and potential exposure pathways, are presented. In addition, exposure factors are discussed, and a preliminary summary of environmental data needs for the BHHRA is provided. Although the problem formulation step is formally part of USEPA's Eight-Step ERA process (USEPA 1997), and as such, is not typically addressed in the HHRA, it is included in the BHHRA portion of this document to provide a roadmap for implementing the fieldwork to support the BHHRA for the NBSA.

5.1 Human Health Conceptual Site Model

An interim human health CSM has been developed and is presented in the Draft Interim Conceptual Site Model Report (Tierra 2011). Based on the review of additional data and reports (i.e., the data and information summarized in this document) and decisions from the BHHERA Workshop (ARCADIS and ToxStrategies 2011), the current human health CSM has been revised and updated and is depicted on Figure 5-1. As more information is collected throughout the RI/FS process, the CSM will be further refined as appropriate. For example, soil may be added as a secondary source as more information about historical floodplains is acquired.

5.2 Human Exposure Scenarios – Current and Future Land Use

As discussed above in Section 3.1.2.2, future land use is not expected to differ significantly from current use; as such, the BHHRA will apply a "combined current and future land use" scenario. It is important to note, however, that the concentrations of COPCs in NBSA environmental media are expected to decrease over time, and this will need to be accounted for in the Feasibility Study.

Additional notable comments and guidance that were considered in the evaluation of current and future land use include:

- USEPA's comments on the Interim CSM (USEPA 2011a) states:

  It is our goal to restore full use of the NBSA as a valuable natural resource for native species and to restore full recreational and commercial use. This would involve improvements in surface water and sediment quality to reduce or remove current fishing and crabbing bans and allow safe wading and swimming.

Therefore, future use should be characterized as higher frequency and duration of use.

- Meeting Minutes from the June 2011 BHHERA Workshop (ARCADIS and ToxStrategies 2011) state that future land use will be documented and considered consistent with USEPA's land use and land reuse guidance (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.7-19) entitled *Considering Reasonably Anticipated Future Land Use and Reducing Barriers to Reuse at EPA-lead Superfund Remedial Sites* (USEPA 2010a), which says:

  Information on surrounding land use may suggest how the site could reasonably be used in the future. Sources and types of information that may aid EPA in determining the reasonably anticipated future land use include: current land use; zoning maps; comprehensive community master plans; accessibility of site to existing infrastructure; recent development patterns; cultural factors; and environmental justice issues. (OSWER Directive No. 9355.7-04, p.5). Discussions with the public, local land use authorities and other appropriate officials should be conducted. "By developing realistic assumptions based on information gathered from these sources early in the RI/FS process, EPA may develop remedial alternatives that are consistent with the anticipated future use" (OSWER Directive No. 9355.7-04, pp. 4-5).

- In addition, from USEPA's land reuse guidance (USEPA 2010a):

  The 1995 Land Use Directive also states that where the remedial action alternatives identified by the Region are not cost-effective or practicable, "the remedial action objective may be revised which may result in different, more reasonable land use(s)…in cases where the future land use is relatively certain, the remedial action objective generally should reflect this land use".

5.3 Human Health Exposure Factors

Where appropriate, exposure factors used for the LPRRP HHRA will be used for the NBSA BHHRA. Where alternative values are proposed for the NBSA, these values will be fully documented. Exposure parameters will rely on site-specific data to the extent feasible, USEPA guidance documents, including the Exposure Factors Handbook (USEPA 2011b), and information in published literature.

5.4 Potentially Exposed Human Populations

Human use of the NBSA includes commercial (e.g., shipping, commerce, industrial, and municipal infrastructure and use) and recreational (e.g., fishing, boating, swimming, and shoreline use) activities. Characterization of these activities is discussed in this section.

A residential scenario will not be evaluated because no properties or shoreline land segments were identified that would be characteristic of a standard residential exposure scenario. While residential properties do border the NBSA, fences and/or walls, significant obstructions, or land-water elevation differences significantly limit human access. These characteristics, as a practical matter, exclude the typical residential exposure scenario for direct contact with NBSA surface water and sediment. Local residents, including those whose properties border the NBSA will be evaluated using the parameters that are applied for the recreational user exposure scenario. The potentially exposed populations and associated site-specific exposure scenarios that will be evaluated are described further below.

5.4.1 Recreational Users

Five recreational areas exist along the eastern shore and one park area borders the western NBSA in the southern portion of the site. Although these parks are along the shore, they primarily offer land-based recreational opportunities, such as baseball diamonds, swing sets, and walking paths (City of Bayonne 2000, 2003) with limited opportunities for direct contact with sediments (Exhibit 5-1).

A desktop evaluation of potential recreational use of the NBSA was conducted by contacting numerous city and county parks and recreation departments, boating companies, and government agencies to characterize recreational activities, such as boating, sail boating, jet skiing, canoeing, and kayaking activities. Appendix C provides a list of entities contacted. The limited information collected from these entities indicates that there are occasional recreational activities that occur in the NBSA. For example, recreational boats travel through the NBSA to get to other areas (e.g., Raritan Bay and the Atlantic Ocean). Information also indicates that fishing is much more common in the NBSA than any other recreational activity. Separate from this assessment, a City of Bayonne document indicates that recreational boating in the NBSA appears to be limited due to commercial traffic and industry (City of Bayonne 2000).

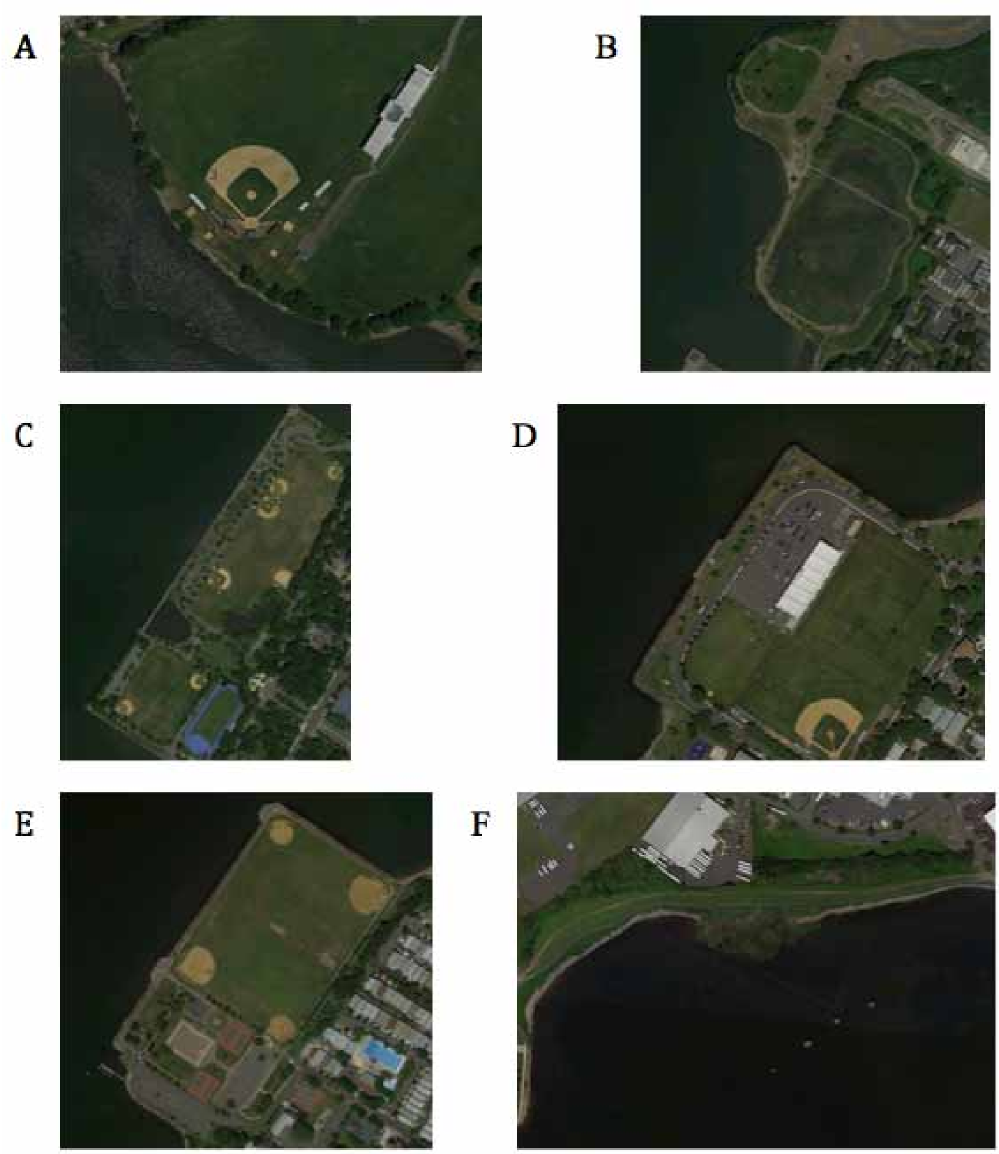

Exhibit 5-1 Recreational Areas

A) Thomas M. Gerrity Athletic Complex, B) Rutkowski Park, C) Bayonne Park, D) Veterans Park, E) 16th Street Park, F) Arthur Kill Park

The possibility of a hunting scenario was also evaluated for the NBSA. Existing hunting regulations were reviewed, and the New Jersey Division of Fish and Wildlife, Bureau of Law Enforcement and the New Jersey State Police were contacted. Research confirmed that hunting is permitted in the NBSA, and there are no Federal Aviation Administration regulations that prevent shooting in the vicinity of Newark Liberty International Airport. State laws govern hunting in the area, including hunting for waterfowl. New Jersey Division of Fish and Wildlife, Bureau of Law Enforcement indicated that they have not observed anyone hunting in the NBSA. Waterfowl hunting is popular in the Hackensack River, and to a lesser extent, in the Passaic River. These data collectively indicate that hunting in the area is not likely to occur, and hunters do not frequent the area.

As previously discussed, there are indications that people actively fish and/or crab along several locations of the NBSA shoreline.

5.4.2 Commercial Users

There are several bridges and other structures located in the NBSA. For instance, the piers/foundations that support the Bayonne and Goethals Bridges are located close to or within the water. As such, pier workers and other commercial/industrial workers (e.g., commercial divers) perform bridge, construction, and repair work in various areas of the NBSA. A number of commercial diving companies, including the U.S. Coast Guard and other entities, were contacted to develop information to characterize potential exposures to industrial workers (Appendix D). Based on the information received to date, commercial divers work on a project-specific basis, with no limit on the number of consecutive days they may dive. Some work 8- to 10-hour days and over 200 days per year.

5.4.3 Transient Users

In order to characterize a potential transient population living along the perimeter of the NBSA, a desktop review was conducted using various internet websites, peer-reviewed literature, publicly available documents describing transient activity in the area, and newspaper archives for the cities and counties surrounding the NBSA. Peer-reviewed literature on the transient population of the NBSA was limited to papers and abstracts that characterized the populations along the Lower Passaic River (e.g., Donovan et al. 2008, Proctor et al. 2002) and not the shoreline of the NBSA.

Publically available documents describing long-term plans to address transient individuals and other community involvement plans were reviewed for details or characterizations of potential transient populations associated with the NBSA. These documents included the following:

- The Hudson County 2010-2014 Five Year Consolidated Plan (Hudson County 2010)

- The Road Home: A Ten Year Plan to End Homelessness in Newark and Essex County (2010-2020) (Essex-Newark Task Force to End Homelessness 2010)

- Lower Passaic River Restoration Project and Newark Bay Study – Community Involvement Plan (Malcolm Pirnie, Inc. 2006)

Malcolm Pirnie, Inc. (2006) indicates that homeless populations are living in several places along the Passaic River and around Newark Bay, but does not identify any specific locations along the actual perimeter of Newark Bay. The report notes that areas where transient populations congregate include “Container City” near Port Newark, an area near Minish Park in Newark, and wooded areas near the Dundee Island in the northern portion of the LPRRP area. The other two documents provide city and county homeless population statistics, but no quantitative or qualitative assessments of individuals along the NBSA.

General internet searches for blogs, community websites, and other information on the transient population in the area did not produce any results.

A search of newspaper archives going back to January 2004 yielded two results related to transient individuals in the NBSA. *The Jersey Journal* reported on March 19, 2012, that a man, presumed to be transient, had been found deceased on the shore of Newark Bay in Bayonne (Conte 2012). The article does not describe any other known transient activity in the area and treats the death as an isolated incident. On September 7, 2010, *The Jersey Journal* reported the homicide of a man on a cove near the Tidelands Athletics Complex (Conte 2010). According to the article, investigators determined that the man had been staying with relatives but had been camping on the shore for a couple of days before the murder. Only a single tent was identified on the shore, and the article did not include any additional details about transient persons frequenting that area.

In summary, peer-reviewed literature, public studies, and long-term community plans do not describe transient populations living along the NBSA itself. Newspaper archives provide only two individual instances of transient persons along the banks of the NBSA. Therefore, while there are occasional descriptions of transient individuals in the area, the information sources reviewed do not indicate that a significant transient population inhabits the NBSA.

5.5 Human Health Exposure Pathways

Based on the human use activities discussed above, it is likely that the current and future human users (i.e., the potentially exposed populations) of the NBSA include anglers/sportsmen, port/dock workers, recreational users, and potential transients (Figure 5-1). The human use activity data also indicate that the media of interest relevant to evaluating potential human health exposures for the NBSA include the following:

- Surface water
- Sediment (intertidal and subtidal to be assessed separately)
- Fish tissue
- Shellfish tissue
- Ambient air

Human exposure pathways were identified based on consideration of the source, release, type, and location of chemicals at the site; the likely environmental fate (including persistence, partitioning, transport, and intermedia transfer) of these chemicals; and the location and activities of the potentially exposed populations. Exposure points (points of potential contact with chemicals) and routes of exposure (e.g., ingestion and inhalation) were identified for each exposure pathway consistent with USEPA guidance (USEPA 1989). The most significant pathway by which people may be exposed to chemical constituents in the NBSA is expected to be from consuming fish and/or shellfish (USEPA 2000a, 2005c). These populations may also be exposed to chemicals through direct contact with sediment and/or surface water during recreational activities, such as fishing, boating, or wading. They may also incidentally ingest chemical constituents from sediment and/or surface water during these activities.

Each of the above-listed routes of exposures will be evaluated quantitatively using algorithms presented in USEPA (1989). The following two pathways will be assessed qualitatively:

- Inhalation of chemicals that may volatilize from the exposed sediment or surface water and pose a threat to humans
- Exposures to a transient population that potentially reside or spend considerable time along the shore

5.5.1 Angler/Sportsman

The angler/sportsman exposure scenario considers adults, adolescents, and children catching and consuming a variety of fish (e.g., striped bass, bluefish, and flounder) and shellfish (e.g., blue crab and soft-shell clams) from the banks of the NBSA. The angler/sportsman scenario for the NBSA includes both a typical angler/sportsman scenario and a subsistence angler/sportsman scenario. As previously discussed, the collection and consumption of fish and shellfish from the NBSA has been documented, and thus, this exposure pathway is considered to be complete. Other potential exposure pathways relevant to the angler/sportsman include direct exposure (i.e., dermal contact and incidental ingestion) of sediment and surface water contacted during these activities. Inhalation of airborne chemicals may also occur if activities occur in intertidal areas, and if VOCs are present in sediments or surface waters.

5.5.2 Recreational Users – Boaters, Swimmers, and Waders

In the BHHRA, three primary recreational uses associated with the NBSA will be evaluated: boating, wading, and swimming. For these scenarios, exposure is primarily via direct contact (i.e., ingestion and dermal contact) with sediment and surface water. Inhalation exposure to VOCs may also occur if activities occur in intertidal areas or near surface water and/or sediments. Ingestion of fish will not be included as a potential exposure pathway for this scenario. Child, adolescent, and adult recreational exposure age categories will be evaluated for each of these recreational scenarios.

5.5.3 Port/Dock Worker – Including Commercial Diver

Port/dock workers have been identified as potentially exposed populations for activities involving repair of piers and pilings or surveying for subsurface (i.e., underwater) construction projects. These workers could potentially be exposed to sediment and surface waters of the NBSA via ingestion, inhalation, and dermal contact. These workers are governed by Occupational Safety and Health Administration (OSHA) in general and, for divers, the OSHA commercial diving regulations (29 Code of Federal Regulations Part 1910, Subpart T – Commercial Diving Operations). However, a review of applicable OSHA documents did not yield information useful for risk assessment purposes. Only the adult age category will be evaluated for this scenario.

5.5.4 Transient

Although transients have been observed in temporary makeshift shelters near the Passaic River (Proctor et al. 2002), it does not appear that transient populations use the NBSA shore in a similar manner. Access to the shore in the industrialized areas of the port is restricted. Other areas, where recreational users have access to the shore, do not appear to support a transient population living along the shore. In addition, the industrialized shoreline of the NBSA limits potential areas for shelter, compared to the Passaic River. Thus, the potential for exposures to transient populations will be evaluated qualitatively, and publically available information will be used to characterize any such population.

5.6 Human Health Risk Assessment Data Needs

5.6.1 Land Use, Zoning, Future Development Plans, and Hunting

As described above, research regarding current and future land use and zoning, the potential for future development and use of the NBSA for hunting is considered complete. Land-use data indicate that future land use and zoning will not be significantly different from current land use and zoning. Any new residential developments will not likely provide significant access to the NBSA or warrant the need for a residential exposure scenario in any area. Based on this research, exposure by hunting will be qualitatively discussed but not included in the quantitative risk assessment.

5.6.2 Environmental Media

Environmental media that need to be collected from the NBSA for the HHRA are: 1) fish and shellfish biological tissue data, and 2) sediment and surface water data from accessible areas. Each is discussed in detail below.

5.6.2.1 *Fish and Shellfish Biological Tissue Data*

Additional measurements of chemical concentrations in fish and shellfish from the NBSA are needed to better characterize the exposures from ingestion from fishing and crabbing. For some species of fish and for some types of chemicals, the data are limited or non-existent. For example, no tissue data are currently available for PCNs or PBDEs, and no data are available for dioxin-like PCB congeners in fish (NJDEP dataset only includes data for these contaminants in crabs). For several chemicals, including dioxins and furans, the data are limited to one white perch fillet, two American eel, and seven striped bass fillet samples. Therefore, future sampling efforts, particularly for fish tissue in the NBSA, representative of multiple edible species and analyzing for all COPCs, including but not limited to, PCNs, PDBEs, dioxins/furans, and dioxin-like PCBs, are necessary.

5.6.2.2 *Intertidal Sediment Concentrations in Accessible Areas*

In areas where the public may access NBSA sediment, including near CSO/SWOs, samples of intertidal sediments should be collected to characterize COPC concentrations in these areas.

5.6.2.3 *Surface Water Concentrations in Accessible Areas*

In areas where the public may access NBSA surface water, including near CSO/SWO outfalls, additional surface water samples should be collected to characterize COPC concentrations in these areas. In addition, COPC concentrations should be evaluated in surface water, sediment, and biological tissue collected from regional “background” locations. However, at this time, an appropriate “background” location has not been identified.

5.6.3 Exposure Factors

While some site-specific information has been collected regarding current port/dock workers (specifically commercial divers) and current recreational exposures, additional information may be collected from more commercial diving, recreational boating companies, and government entities. For example, for estimating current exposures for the port/dock worker and the recreational user, additional data to estimate exposure frequency and duration would help delineate these scenarios more accurately.

6. Next Steps

This document presents Step 3 of the eight-step ERA process (Problem Formulation), which includes a CSM with identified exposure pathways and receptors, AEs, as well as the pertinent risk questions to be answered via data collection and analysis. Next, Step 4 will include the development of work plans, field sampling plans, and QAPPs, followed by data collection (Step 5), analysis (Step 6), risk characterization (Step 7), and risk-based decision making (Step 8).

The following work plans are anticipated to be developed during the next step of the process:

- **Field Survey/Reconnaissance Work Plan** will discuss how to physically document and characterize the possible ecological habitats in the NBSA, including the shoreline and intertidal areas. In addition, the reconnaissance survey will identify potentially accessible areas for the BHHRA. During this reconnaissance, a mammal survey will also be performed.

- **Surface Water and Sediment Sampling and Analysis Plan (SAP)/QAPP** will describe, in detail, the proposed stations and methodology for collecting and analyzing surface water and surficial sediment in the NBSA. Information will be provided regarding the collection of sediment and surface water for laboratory analysis, as well as the methodology for the collection and analysis of benthic invertebrate community metrics.

- **Toxicity/Bioaccumulation Studies Work Plan** will describe, in detail, the proposed toxicity and bioaccumulation studies to evaluate potential adverse effects to fish and invertebrates exposed to media from the NBSA.

- **Fish and Blue Crab SAP/QAPP** will describe, in detail, the proposed sampling methodology for collecting and analyzing fish and blue crabs from the NBSA.

- **Risk Assessment and Risk Characterization (RARC) Work Plan** will describe how the baseline risk assessments will be conducted, including sections for both the BERA and BHHRA. A methodology for the calculation of exposure point concentrations will be presented. For the BERA, TRVs, CBRs, and species-specific exposure parameters for the wildlife food web dose models will be selected. In addition, a discussion regarding the risk characterization based on the SQT approach will be provided. For the BHHRA, information from the PAR

(USEPA 2006b) will be updated and incorporated, as appropriate. COPCs will be identified using the approach previously approved by USEPA for the LPRRP HHRA (Windward 2012). RAGS Part D Tables 1 through 6 will also be prepared and incorporated into the RARC.

7. References

Academy of Natural Sciences. 2006. *Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey. Second Year of Routine Monitoring Program*. Final Report. Report No. 06-04F.

AECOM. 2011. *Quality Assurance Project Plan/Field Sampling Plan Addendum Remedial Investigation Water Column Monitoring/Small Volume Chemical Data Collection Lower Passaic River Restoration Project*. Revision 1.

ARCADIS and ToxStrategies. 2011. Memorandum from ARCADIS and ToxStrategies to Tierra. Re: *Revised Meeting Minutes – Baseline Human Health and Ecological Risk Assessment Workshop June 28-29, 2011*. December 1.

ATSDR. 1995. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. August.

ATSDR. 2004. *Toxicological Profile for Copper.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. September.

ATSDR. 2005. *Toxicological Profile for Zinc.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. August.

Anderson, J.R., E.E. Hardy, J.T. Roadh, and R.E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. *Professional Paper 964.* U.S. Geological Survey, Reston, VA.

Ankley, G.T, D.M. DiToro, D.J. Hansen, and W.J. Berry. 1996. Technical basis and proposal for deriving sediment quality criteria for metals. *Environ. Toxicol. Chem*. 15:2056-2066.

Battelle. 1992. Sediment Toxicity and Concentrations of Trace Metals in Sediment and Porewater in New York/New Jersey Harbor. Ocean Sciences, Duxbury, MA. Submitted to New York City Department of Environmental Protection.

Battelle. 1997a. Evaluation of Dredged Material Proposed for Ocean Disposal from Arthur Kill Project Area, New York. Battelle, Sequim, WA.

Battelle. 1997b. Evaluation of Dredged Material Proposed for Ocean Disposal from Hackensack River Project Area, New York. Battelle, Sequim, WA.

Becvar, N. and G.R. Lotufo. 2011. DDT and other organohologen pesticides in aquatic organisms. In: *Environmental Contaminants in Biota, Interpreting Tissue Concentrations*. 2nd Ed. Edited by W.N. Beyer and J.P. Meador. CRC Press, Boca Raton, FL.

Berlin, W.H., R.J. Hesselberg, and M.J. Mac. 1981. Growth and mortality of fry of Lake Michigan lake trout during chronic exposure to PCBs and DDE. Pp. 11-22. In: *Chlorinated Hydrocarbons as a Factor in the Reproduction and Survival of Lake Trout (*Salvelinus namaycush*) in Lake Michigan.* U.S. Fish and Wildlife Service Technical Paper 105.

Bernick, A.J. 2007. *NYC Audubon's Harbor Herons Project: 2007 Nesting Survey.* NYC Audubon, New York. 48 pp.

Bernick, A.J. and E. Craig. 2008. *NYC Audubon's Harbor Herons Project: 2008 Interim Nesting Survey.* NYC Audubon, New York. 42 pp. 2007

Bonnevie, N.L., S.L. Huntley, B.W. Found, and R.J. Wenning. 1994. Trace metal contamination in surficial sediments from Newark Bay, New Jersey. *Sci. Total Environ*. 144:1-16.

Brown, R.P., K.R. Cooper, A. Crisini, C. Rappe, and P-A. Bergqvist. 1994. Polychlorinated dibenzo-*p*-dioxins and dibenzofurans in *Mya arenaria* in the Newark/Raritan Bay Estuary. *Environ. Toxicol. Chem.* 13(3):523-528.

Brydon, N.F. 1974. *The Passaic River: Past, Present, Future.* Rutgers University Press, New Brunswick, NJ.

Bugel, S.M. 2009. *An Integrated Biomarker Approach for Assessing Exposure and Effects of Endocrine Disruptors and other Contaminants in Killifish (*Fundulus heteroclitus*) from the New York-New Jersey Harbor Estuary*. Theses or Dissertation. Rutgers University.

Bugel, S.M. 2011. *Decreased Vitellogenin Inducibility and 17β-estradioal Levels Correlated with Reduced Egg Production in Killifish (*Fundulus heteroclitus*) from Newark Bay, NJ*. Doctoral Dissertation. Rutgers University.

Burger, J. 2002. Consumption patterns and why people fish. *Environ Res A* 90:125-135.

Burger, J. 2003. Assessing perceptions about ecosystem health and restoration options in three East Coast estuaries. *Environ Monitor Assess* 83:145-162.

Burger, J., K.K. Pflugh, L. Lurig, L.A. Von Hagen, and S. Von Hagen. 1999. Fishing in urban New Jersey: Ethnicity affects information sources, perception, and compliance. *Risk Anal* 19(2):217–229.

Burgess, R.M. 2009. *Evaluating Ecological Risk to Invertebrate Receptors from PAHs in Sediments at Hazardous Waste Sites.* EPA/600/R-06/162F/ERASC-011F. USEPA Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division. Narragansett, RI.

Butler, E. 2008. Personal communication from Elizabeth Butler, USEPA Region II, dated May 16, 2008. Re: *Secondary Data Evaluation*.

Chant, R.J. 2006. *Hydrodynamics of the Newark Bay/Kills System: The New Jersey Toxics Reduction Workplan for New York-New Jersey Harbor Study I-E.* Prepared for the New Jersey Department of Environmental Protection, Division of Science, Research, and Technology.

City of Bayonne. 2000. *City of Bayonne Master Plan 2000.* Available online at: http://www.bayonnenj.org/masterplan.

City of Bayonne. 2001. *City of Bayonne Zoning Map.* Prepared by Heyer, Gruel & Associates, PA.

City of Bayonne. 2003. *City of Bayonne Parks and Playgrounds.* Available online at: http://www.bayonnenj.org/parks.htm. Accessed January 2011.

City of Elizabeth. 2012. *City of Elizabeth Zoning Map.* Prepared by Harbor Consultants, Inc. February 21, 2000; revised 2012.

City of Kearny. 2009. *Kearny Zoning.* Available online at www.kearnyusa.com/sites/default/.../Kearny%20Zoning%202009.pdf.

City of Newark. 2004. *Existing Land Use Map*. November. Available online at www.ci.newark.nj.us/.

Conte, M. 2010. Body of Jersey City Man Found in Newark Bay was Fatally Shot, Prosecutor Says. *The Jersey Journal.* Hudson County.

Conte, M. 2012. Police Hope Tattoo Will Help Identify Body of Man Found on Bayonne Shoreline. *The Jersey Journal.* Hudson County.

Cooper, K.R. and G.A. Buchanan. 2007. *Integrated Biomarkers for Assessing the Exposure and Effects of Endocrine Disruptors and Other Contaminants on Marine/Estuarine Fish.* Second Year Grant Number SR03-038. Rutgers University Cook College and the Department of Environmental Protection.

Crawford, D.W., N.L. Bonnevie, C.A. Gillis, and R.J. Wenning. 1994. Historical changes in the ecological health of the Newark Bay Estuary, New Jersey. *Ecotoxicol Environ Safety* 29:276-303.

Crawford, D.W., N.L. Bonnevie, and R.J. Wenning. 1995. Sources of pollution and sediment contamination in Newark Bay, New Jersey. *Ecotoxicol Environ Safety* 30:85-100.

Cunningham, J.T. 1954. *Made in New Jersey: The Industrial Story of a State.* Rutgers University Press, New Brunswick, NJ.

Cunningham, J.T. 1966a. *Newark.* Revised and expanded New Jersey Historical Society, Newark, NJ.

Cunningham, J.T. 1966b. *New Jersey: America's Main Road.* Doubleday & Company, New York, NY.

Daniels R.A., K.E. Limburg, R.E. Schmidt, D.L. Strayer, and R.C. Chambers. 2005. Changes in fish assemblages in the tidal Hudson River, New York. *Am Fish Sym* 45:471-503.

Dewey, T. and E. Ellis. 2003. *Lontra Canadensis*. Animal Diversity Web. Accessed on August 03, 2010 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Lontra_canadensis.htht.

DiToro, D.M., J.D. Mahony, D.J. Hansen, K.J. Scott, M.B. Hicks, S.M. Mayr, and M.S. Redmond. 1990. Toxicity of cadmium in sediments: the role of acid volatile sulfide. *Environ. Toxicol. Chem*. 9:1487-1502.

DiToro, D.M., C.S. Zarba, D.J. Hansen, W.J. Berry, and J.C. Swartz. 1991. Technical basis for establishing sediment quality criteria for non-ionic organic chemicals using equilibrium partitioning. *Env. Sci. Technol*. 37:735-741.

Donovan, E., K. Unice, J.D. Roberts, M. Harris and B. Finley. 2008. Risk of gastrointestinal disease associated with exposure to pathogens in the water of the Lower Passaic River. *Appl Environ Microb* 74(4): 994-1003.

Douglas, W.S., L.J. Baier, R.J. Gimello, and J. Lodge. Undated. A Comprehensive Strategy for Managing Contaminated Dredged Materials in the Port of New York and New Jersey. Undated Manuscript. Available online at: http://www.state.nj.us/transportation/airwater/maritime/pdf/compstrategy.pdf.

Duffy-Anderson, J.T., J.P. Manderson, and K.W. Able. 2003. A characterization of juvenile fish assemblages around man-made structures in the New York-New Jersey Harbor Estuary, USA. *Bull. Marine Sci.* 72(3):877-889.

Eastern Roads. 2012. Arthur Kill Railroad Lift Bridge Historic Overview. Available online at: http://www.nycroads.com/crossings/arthur-kill/.

Eisler, R. 1986. *Polychlorinated Biphenyl Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* Biological/Contaminant Hazard Review Report 85(1.7). U.S. Fish and Wildlife Service. April.

Eisler, R. 1987a. *Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* Biological report 85(1.10)/Contaminant Hazard Review Report No. 10. U.S. Fish and Wildlife Service. April.

Eisler, R. 1987b. *Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. Biological/Contaminant Hazard Review Report 85(1.11). U.S. Fish and Wildlife Service. May.

Eisler, R. 1990. *Chlordane Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. Biological/Contaminant Hazard Review Report 33. U.S. Fish and Wildlife Service. January.

Eisler, R. 1998. *Copper Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. Biological/Contaminant Hazard Review Report 85(1.21). U.S. Fish and Wildlife Service. July.

Eisler, R and A. Belisle. 1996. *Planar PCB Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* Biological/Contaminant Hazard Review Report 31. U.S. Fish and Wildlife Service. August.

Elliott, J.E. and C.A. Bishop. 2011. *Cyclodiene and Other Organochlorine Pesticides in Birds. In: Environmental Contaminants in Biota, Interpreting Tissue Concentrations.* 2nd Ed. Edited by W.N. Beyer and J.P. Meador. CRC Press, Boca Raton, FL.

Ellis, R.H, S.J, Koepp, J. Weiss, E.D. Santoro, and S.L. Cheng. 1980. *A Comprehensive Monitoring and Assessment Program for Selected Heavy Metals in New Jersey Aquatic Fauna*. New Jersey Marine Sciences Consortium.

Elphick, C., J.D. Dunning, and D.A. Sibley (Eds.). 2001. *The Sibley Guide to Bird Life and Behavior.* Alfred A. Knopf, New York.

Essex-Newark Task Force to End Homelessness. 2010. *The Road Home: A Ten Year Plan to End Homelessness in Newark and Essex County (2010-2020).*

Fernandez M.P., M.G. Ikonomou, S.C. Courtenay, and I.I. Wirgin. 2004. Spatial variation in hepatic levels and patterns of PCBs and PCDD/Fs among young-of-the-year and adult Atlantic tomcod (*Microgadus tomcod*) in the NY/NJ Harbor Estuary*. Environ Sci Technol* 38: 976-983.

Gale, R.W., E.R. Long, T.R. Schwartz, and D.E. Tillitt. 2000. Evaluation of planar halogenated and polycyclic aromatic hydrocarbons in estuarine sediments using ethoxyresorufin-*O*-deethylase induction of H4IIE cells. *Environ. Toxicol. Chem.* 19(5):1348-1359.

Gelb, Y. 2004. *NYC Audubon Harbor Herons Shore Monitoring Program: Data and Findings. June 3-August 15.* Prepared for NYC Audubon, New York. 17 pp.

Gillis, C.A., N.L. Bonnevie, and R.J. Wenning. 1993. Mercury contamination in Newark Bay Estuary. *Ecotoxicol Environ Safety* 25:214-226.

Gillis, C.A., N.L. Bonnevie, S.H. Su, J.G. Ducey, S.L. Huntley, and R.J. Wenning. 1995. DDT, DDD, and DDE contamination of sediment in the Newark Bay Estuary, New Jersey. *Arch Environ Contam Toxicol* 28:85-92.

Gunster, D.G., C.A. Gillis, N.L. Bonnevie, T.B. Abel, and R.J. Wenning. 1993a. Petroleum and hazardous chemical spills in Newark Bay, New Jersey, USA from 1982 to 1991. *Environ Poll* 82:245-253.

Gunster, D.G., N.L. Bonnevie, C.A. Gillis, and R.J. Wenning. 1993b. Assessment of chemical loadings to Newark Bay, New Jersey from petroleum and hazardous chemical accidents occurring from 1986 to 1991. *Ecotoxicol Environ Safety* 25:202-213.

Harbor Herons Subcommittee. 2010. *Harbor Herons Conservation Plan – NY/NJ Harbor Region.* NY-NJ Harbor Estuary Program. Edited by S.B. Elbin and N.K. Tsipoura.

Herrington, T.O., K.L. Rankin, and M.S. Bruno. 2002. Frequency of sediment suspension events in Newark Bay. *Proceedings of the International Conference "Protection and Restoration of the Environment VI".* Skiathos July 1-5:371-378.

Hoffman, D. J., Rattner, B.A., Burton, G. A., and J. Cairns. 1995. *Handbook of Ecotoxicology*. CRC Press, Boca Raton.

Honeywell. 1999-2006. *Offshore Investigation Results Summary Report*.

Horwitz, R.J., D.J. Valinksky, P. Overbeck, P. Kiry, and B.E. Ruppel. 2002. Environmental Assessment and Risk Analysis Element Research Project Summary: Assessment of Total Mercury Concentrations in Fish from Rivers, Lakes and Reservoirs in New Jersey. Available online at http://www.state.nj.us/dep/dsr/research/mercury-fish.pdf.

Horwitz, R.J., P.F. Overbeck, J. Ashley, D. Velinsky, and L. Zadoudeh. 2006. *2004 Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey.* Report No. 06-04 Second Year of Routine Monitoring Program Final Report. NJ contract SR-04073 ANS: Project # 895.

Hsiao. S.M., M.S. Greeley Jr., and R.A. Wallace. 1994. Reproductive cycling in female *Fundulus heteroclitus. Biol Bull* 186:271-284.

Hudson County. 2010. *Hudson County 2010-2014 Five Year Consolidated Plan.* Submitted to: The U.S. Department of Housing and Urban Development Newark Area Office.

Huntley, S.L., N.L. Bonnevie, and R.J. Wenning. 1995. Polycyclic aromatic hydrocarbon and petroleum hydrocarbon contamination in sediment from the Newark Bay Estuary, New Jersey. *Arch Environ Contam Toxicol* 28:93-107.

Hydroqual. 2007. *A Model for the Evaluation and Management of Contaminants of Concern in Water, Sediment, and Biota in the NY/NJ Harbor Estuary Contaminant Fate & Transport & Bioaccumulation Sub-models.* Contaminant Assessment and Reduction Project. July.

Iannuzzi, T.J. and D.F. Ludwig. 2004. Historical and current ecology of the lower Passaic River. *Urban Habitats* 2(1):147-173.

Iannuzzi, T.J., S.L. Huntley, N.L. Bonnevie, B.L. Finley, and R.J. Wenning. 1995. Distribution and possible sources of polychlorinated biphenyls in dated sediments from the Newark Bay Estuary, New Jersey. *Arch Environ Contam Toxicol* 28:108-117.

Iannuzzi, T.J., D.F. Ludwig, J.C. Kinnell, J.M. Wallin, W.H. Desvousges, and R.W. Dunford. 2002. *A Common Tragedy: History of an Urban River.* First edition. Amherst Scientific Publishers, Amherst, MA.

Iocco, L.E., P. Wilber, R.J. Diaz, D.G. Clarke, and R.J. Will. 2000. *Final Report. Benthic Habitats of New York/New Jersey Harbor: 1995 Survey of Jamaica, Upper, Newark, Bowery, and Flushing Bays.* National Oceanic and Atmospheric

Administration, Virginia Institute of Marine Sciences, and U.S. Army Corps of Engineers.

IPCS. 1992. *Environmental Health Criteria 135: Cadmium – Environmental Aspects.* World Health Organization. Geneva.

Jersey City. 2001. *Jersey City Zoning Map.* City of Jersey City Planning, adopted April 11.

Jersey City. 2008. *Bayfront I Redevelopment Plan.* February.

Kerlinger, P. 2004. *NYC Audubon's Harbor Herons Project: 2004 Nesting Survey.* NYC Audubon, New York. 30 pp.

LMS. 1996. *Biological Survey of Newark Bay Shoal Areas and Adjacent Kill Van Kull and Arthur Kill Channels.* Lawler, Matusky and Skelly Engineers, Inc. Prepared for the Port Authority of New York and New Jersey.

Loseto, L.L., and P.S. Ross. 2011. Organic Contaminants in Marine Mammals. In: *Environmental Contaminants in Biota, Interpreting Tissue Concentrations.* 2nd Edition. Edited by W.N. Beyer and J.P. Meador. CRC Press, Boca Raton, FL.

Ludwig, D.F., J. Iannuzzi, T.J. Iannuzzi, and J.K. Shisler. 2010. Spatial and temporal habitat use patterns by water birds in an urban estuarine ecosystem: Implications for ecosystem management and restoration. *Human Ecol Risk Assess* 16(1):163-184.

MacDonald Environmental Sciences Ltd. and Cantox Environmental, Inc. 2004. *Considerations for Developing Problem Formulations for Ecological Risk Assessments Conducted at Contaminated Sites under CERCLA: A Discussion Paper.* October.

Malcolm Pirnie Inc. 2006. *Lower Passaic River Restoration Project / Newark Bay Study Community Involvement Plan (CIP).* June.

May, H. and J. Burger. 1996. Fishing in a polluted estuary: Fishing behavior, fish consumption, and potential risk. *Risk Anal* 16(4):459-471.

McGeer J, K.V. Brix, J.M. Skeaff, D.K. DeForest, S.I, Brigham, W.J. Adams, and A. Green. 2003. Inverse relationship between bioconcentration factor and exposure concentration for metals: Implications for hazard assessment of metals in the aquatic environment. *Environ Toxicol Chem* 22(5):1017-1037.

McKinney, J.D. and C.L. Walker. 1994. Polychlorinated biphenyls as structurally active hormonal analogues. *Environmental Health Perspectives* 102, 290-297.

Meyers, W.S. 1945. *The Story of New Jersey.* Vols. 1-4. Lewis Historical Publishing, New York, NY.

Mizrahi, D.S., N. Tsipoura, and K. Witkowski. 2007. *Avian Abundance and Distribution in the New Jersey Meadowlands District: The Importance of Habitat, Landscape, and Disturbance.* New Jersey Audubon Society. A Final Report Submitted to New Jersey Meadowlands Commission. November 28.

Nacci, D., L. Coiro, D. Champlin, S. Jayaraman, R. McKinney, T.R. Gleason, W.R. Munns Jr., J.L. Specker, and K.R. Cooper. 1999. Adaptations of wild populations of the estuarine fish *Fundulus heteroclitus* to persistent environmental contaminants. *Marine Bio* 134:9-17.

National Aquarium. 2010. *Diamondback Terrapin.* Available online at: http://www.aqua.org/animals_diamondbackterrapin.html.

Newark Bay Study Area Coordination Team Meeting. 2012. Newark Bay Study Area Coordination Team Meeting, June 7, 2012. Memorandum for Record.

New Jersey Harbor Dischargers Group. 2008. *Harbor-Wide Water Quality Monitoring Report for the New York-New Jersey Harbor Estuary*.

New York City. 2011a. *Zoning Map 20c.* New York City Planning Commission. May 5.

New York City. 2011b. *North Shore 2030.* Department of City Planning and the New York City Economic Development Corporation. December.

NJDEP. 1982. *PCBs in Fish: 1975-1980. A Comprehensive Survey.* Office of Cancer and Toxic Substances Research.

NJDEP. 1983. *PCBs in Selected Finfish Caught Within New Jersey Waters 1981-1982 (With Limited Chlordane Data).* July.

NJDEP. 1985. *A Study of Dioxin (2,3,7,8-Tetrachlorodibenzo-p-Dioxin) Contamination in Select Finfish, Crustaceans and Sediments of New Jersey Waterways.* Office of Science and Research.

NJDEP. 2008. *Annual Summary of Phytoplankton Blooms and Related Conditions in the New Jersey Coastal Waters. Summer 2005.* Report Prepared By: William Heddendorf, Environmental Specialist Bureau of Marine Water Monitoring.

NJDEP. 2009a. *Remote Sensing*. Available online at: http://www.nj.gov/dep/bmw/remotesensing.htm.

NJDEP. 2009b. *Ecological Screening Table*. Last updated March 10. Available online at: http://www.nj.gov/dep/srp/guidance/ecoscreening/.

NJDEP and NJDHSS. 2012. *Fish Smart, Eat Smart – A Guide to Health Advisories for Eating Fish and Crabs Caught in New Jersey Waters*. Available online at: http://www.state.nj.us/dep/dsr/2012-advisory-report.pdf.

NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.

NOAA. 1995. *Magnitude and Extent of Sediment Toxicity in the Hudson Raritan Estuary.* NOAA Technical Memorandum NOS ORCA 88. National Oceanic and Atmospheric Administration, Silver Spring, MD.

NOAA. 1997. *Fish, Megainvertebrates, and Associated Hydrographic Observations Collected in Newark Bay, New Jersey, during May 1993 – April 1994*. Report prepared by U.S. Department of Commerce, National Oceanic and Atmospheric Administration , National Marine Fisheries, and Northeast Fisheries Science Center. Also available online at: http://sh.nefsc.noaa.gov.

NOAA. 1998. *Tide Tables 1998.* National Oceanic and Atmospheric Administration, National Ocean Service, U.S. Department of Commerce, Washington, D.C.

NOAA. 2005. *Benthic Macrofauna and Associated Hydrographic Observations Collected in Newark Bay, New Jersey, between June 1993 and March 1994*. Report prepared by U.S. Department of Commerce, National Oceanic and Atmospheric Administration , National Marine Fisheries, and Northeast Fisheries Science Center. Also available online at: http://sh.nefsc.noaa.gov.

NOAA. 2007. The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2006 (and Other Frequently Requested Hurricane Facts). Technical Memorandum NWS TPC-5. April. Available online at: http://www.nhc.noaa.gov/pdf/NWS-TPC-5.pdf.

NOAA. 2011. *Historical Floods: Passaic River at Little Falls. Period of Record: 1903-Present.* September. Available online at: http://www.erh.noaa.gov/marfc/Rivers/FloodClimo/Pointfloods/Psc/LittleFalls-PSC-%20PointFloods-Table.pdf.

NRCC. 1975. *Chlordane: Its Effects on Ecosystems and its Chemistry.* National Research Council Canada. Publ. NRCC 14094. 189 pp.

NYCT. 2011. New York Container Terminal History. Available online at: http://www.nycterminal.com/t3/index.php?id=240. Accessed April 26, 2012.

NYSDEC. 2003. *Contamination Assessment and Reduction Project (CARP): Water.* Final Report. New York State Department of Environmental Conservation, Bureau of Water Assessment and Management, Division of Water.

NYSDEC. 2004a. *Dioxins and Furans in Five Fish Species, Blue Crabs, Invertebrates, and Zooplankton from the New York-New Jersey Harbor Estuary.* New York State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources. Contaminant Assessment and Reduction Program.

NYSDEC. 2004b. *Mercury, Methyl Mercury, Cadmium, and Lead in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary.* New York State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources. Contaminant Assessment and Reduction Program.

NYSDEC. 2004c. *Polychlorinated Biphenyls (PCBs) in Five Fish Species from the New York-New Jersey Harbor Estuary.* New York State Department of Environmental

Conservation, Division of Fish, Wildlife, and Marine Resources. Contaminant Assessment and Reduction Program.

NYSDEC. 2005. *Organochlorine Pesticides in Five Fish Species, Blue Crabs, Invertebrates, and Zooplankton from the New York-New Jersey Harbor Estuary.* New York State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources. Contaminant Assessment and Reduction Program.

NYSDEC. 2006. *Polynuclear Aromatic Hydrocarbons (PAHs) in Five Fish Species, Blue Crabs, Invertebrates, and Zooplankton from the New York-New Jersey Harbor Estuary.* New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. Contaminant Assessment and Reduction Program.

NYT. 1891. News About Railroads. January 15.

NYT. 1913a. Newark Bay Bridge Destroyed By Fire. 16 June. Archive.

NYT. 1913b. Bridge a Mile Long Rebuilt in 12 Days. 11 August. Archive.

NYT. 1926. Jersey’s Waste Meadows to be Reclaimed. By Rose C. Feld. 25 July. ProQuest Historical Newspapers The New York Times (1851 – 2007). Archive.

NYT. 1927a. To Start New Bridge Soon, Lehigh Valley and P.R.R. Will Build Span Over Newark Bay. March 6.

NYT. 1927b. Two New Jersey Bridges Approved. May 18.

NYT. 1927c. Newark Airport Plans. 4 August. ProQuest Historical Newspapers The New York Times (1851 – 2007).

NYT. 1927d. Port Newark Sees Progress in 1928. 26 December. ProQuest Historical Newspapers The New York Times (1851 – 2007).

NYT. 1955. Newark Bay Span is One-Third Done. February 15.

NYT. 1972. Port Newark-Elizabeth Complex Becoming the World's Container Capital. By Ania Savages. ProQuest historical newspapers The New York Times (1851-2007). 23 July.

NYT. 1999. If You're Thinking of Living in Garfield, N.J.; Where Immigrants Feel Right at Home. By Jerry Cheslow. Real Estate. 12 September. Available online at: http://www.nytimes.com/1999/09/12/realestate/if-you-re-thinking-of-living-in-garfield-nj-where-immigrants-feel-right-at-home.html. Accessed March 28, 2012.

NYT. 2011. Living in Oradell, NJ; Activating Homing Devices. By Jill P. Capuzzo. Real Estate. 4 December. Available online at: http://query.nytimes.com/gst/fullpage.html?res=9803E0D61539F937A35751C1A9679D8B63&scp=3&sq=Living%20in%20Oradell&st=cse&pagewanted=1. Accessed March 28, 2012.

OEHHA. 2009. *Toxicological Profile for di-(2-ethylhexyl) phthalate (DEHP).* California Department of Environmental Protection, Office of Environmental Health Hazard Agency.

PANYNJ. 2012a. History of the Port Authority. Online summary. Available online at: http://www.panynj.gov/about/history-port-authority.html. Accessed April 4, 2012.

PANYNJ. 2012b. History of Newark Liberty International Airport. Online Summary. Available online at: http://www.panynj.gov/airports/ewr-history.html. Accessed April 26, 2012.

PANYNJ. 2012c. Goethals Bridge History. Online Summary. Available online at: http://www.panynj.gov/bridges-tunnels/goethals-bridge-history.html. Accessed April 26, 2012.

PANYNJ. 2012d. Bayonne Bridge History. Online Summary. Available online at: http://www.panynj.gov/bridges-tunnels/bayonne-bridge-history.html. Accessed April 26, 2012.

Parsons, K.C. 2003. *Chemical Residues in Cormorants from New York Harbor and Control Location.* Contract No. C003858. Submitted to NYSDEC February 28.

Pence, A.M. 2004. *Dominant Forces in an Estuarine Complex with Multiple Tributaries and Free Connections to the Open Ocean with Application to Sediment*. Ph.D. Dissertation, Stevens Institute of Technology, Hoboken.

Peters, R.E.M., S.C. Courtenay, S. Cagampan, M.L. Hewitt, and D.L. MacLatchy. 2007. Effects on reproductive potential and endocrine status in the mummichog (*Fundulus heteroclitus*) after exposure to 17α-ethynylestradiol in a short-term reproductive bioassay. *Aquatic Toxicol* 85:154-166.

Pflugh, K.K., L. Lurig, L.A. Von Hagen, S. Von Hagen, and J. Burger. 1999. Urban anglers' perception of risk from contaminated fish. *Sci Total Environ* 228:203-218.

Pflugh, K., A. Stern, L. Nesposudny, L. Lurig, B. Ruppel, and G. Buchanan. 2011. Consumption patterns and risk assessment of crab consumers from the Newark Bay Complex, New Jersey, USA. *Sci Total Environ* doi:10.1016/j.scitotenv.2011.07.017.

Proctor, D.M., S. Su and B.L. Finley. 2002. Multi-media exposure scenario survey for defining the conceptual site model of a human health risk assessment for a river in a highly urbanized area. Presented at the *2002 Annual Meeting of the Society of Risk Analysis*. December 9.

Rappe, C., P-A. Bergqvist, L-O. Kjeller, S. Swanson, T. Belton, B. Ruppel, K. Lockwood, and P.C. Kahn. 1991. Levels and patterns of PCDD and PCDF contamination in fish, crabs, and lobsters from Newark Bay and the Newark Bight. *Chemosphere* 22(3-4):239-266.

Rice, C.A., P.D. Plesha, E. Casillas, D.A. Misitano, and J.P. Meador. 1995. Growth and survival of three marine invertebrate species in sediments from the Hudson-Raritan Estuary, New York. *Environ. Toxicol. Chem.* 14(11):1931-1940.

Schoor DePalma, Inc. 2005. *Master Plan. City of Elizabeth, Union County, New Jersey.* Prepared for City of Elizabeth Planning Board. October.

Tierra. 2004. *Newark Bay Study Area RIWP. Sediment Sampling and Source Identification Program. Volume 1 of 3. Inventory Report.* Revision 0. Tierra Solutions, Inc., East Brunswick, New Jersey. June.

Tierra. 2005. *Newark Bay Study Area Remedial Investigation Work Plan. Volume 2.* Revision 1. Tierra Solutions, Inc., East Brunswick, NJ. September.

Tierra. 2007. *Newark Bay Study Area Remedial Investigation Work Plan, Phase II.* Revision 2, Amendment 1. Tierra Solutions, Inc., East Brunswick, NJ. November.

Tierra. 2008a. *Estimation of the Biologically Active Zone, Newark Bay, New Jersey.* Revision 2. Prepared by Dr. Robert Diaz and ARCADIS. Tierra Solutions, Inc., East Brunswick, New Jersey. September.

Tierra. 2008b. *Phase I and Phase II Sediment Investigation Field and Data Report. Newark Bay Study Area Remedial Investigation.* Revision 0. Tierra Solutions, Inc., East Brunswick, New Jersey. December.

Tierra. 2010a. *Phase I and Phase II Data Evaluation and Analysis Report. Newark Bay Study Area Remedial Investigation.* Revision 0. Tierra Solutions, Inc., East Brunswick, New Jersey. April.

Tierra. 2010b. Letter to Elizabeth Butler (USEPA) Re: *Phase II Additional Data, Administrative Order on Consent, USEPA. Index No. CERCLA-02-2004-2010 for Newark Bay Study Area – Remedial Investigation*. Tierra Solutions, Inc., East Brunswick, New Jersey. May 18.

Tierra. 2011. *Interim Conceptual Site Model.* Tierra Solutions, Inc., East Brunswick, New Jersey. February.

United States Coast Guard. 2010. *Goethals Bridge Replacement Project Final Environmental Impact Statement.* Volumes 1-3. August.

USACE. Undated. *Essential Fish Habitat Assessment for Newark Bay Maintenance Dredging: Newark Bay – Port Newark Channel, Port Newark Pierhead Channel, and Port Elizabeth Channel of Newark Bay, Hackensack and Passaic Rivers Federal Navigation Project.* Prepared by USACE, New York, New York. 26 pp.

USACE. 1997. *Final Environmental Impact Statement on the Newark Bay Confined Disposal Facility.* U.S. Army Corps of Engineers, New York District, New York, New York. April.

USACE. 1999a. Draft Feasibility Report for New York and New Jersey Harbor Investigation Study. Draft Environmental Impact Statement (DEIS). U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 1999b. *New York and New Jersey Harbor Navigation Study. Biological Monitoring Program 1998-1999, Volume I of II*. U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2003. *Aquatic Biological Sampling Program 1998–2003.* Raw data in Access database. New York and New Jersey Harbor Navigation Project. U.S. Army Corps of Engineers, New York District, New York, New York. August.

USACE. 2004a. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2004b. *Essential Fish Habitat Assessment. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2005. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2006a. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2006b. *Geomorphological/Geophysical Characterization of the Nature and Dynamics of Sedimentation and Sediment Transport in Newark Bay focusing on the Effects related to Continued and Future Navigation Channel Deepening and Maintenance.* Contract #W912DS-06-D-0001. Delivery Order #0004. U.S. Army Corps of Engineers, New York District. 31 December.

USACE. 2007a. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2007b. *Final Environmental Assessment. Effects of the NY/NJ Harbor Deepening Project on the Remedial Investigation/Feasibility Study of the Newark Bay Study Area.* U.S. Army Corps of Engineers, New York District. June.

USACE. 2007c. *Final Report. 2006 Migratory Finfish Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2008a. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2008b. *Dredged Material Analysis Tools. Performance of Acute and Chronic Sediment Toxicity Methods*. USACE, Engineer Research and Development Center, Dredging Operations and Environmental Research Program.

USACE. 2009. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2010a. *Determining Steady-State Tissue Residues for Invertebrates in Contaminated Sediment.* USACE, Engineer Research and Development Center, Dredging Operations and Environmental Research Program. May.

USACE. 2010b. *Stratified Sampling Project Summary Report and Evaluation of Data.* U.S. Army Corps of Engineers, New York District, New York, New York.

USACE. 2011. *New York and New Jersey Harbor (50 Ft. Deepening) Navigation Project. Fact Sheet.* U.S. Army Corps of Engineers – New York District 26 Federal Plaza, New York, NY. Available online at: http://www.nan.usace.army.mil/project/newjers/factsh/pdf/nynj.pdf.

USACE. 2012a. *Passaic River Mainstem and Tributaries, New Jersey: Flood Risk Management and Restoration Projects. Project Fact Sheet.* February. Available online at: http://www.nan.usace.army.mil/project/newjers/factsh/pdf/passaic.pdf.

USACE. 2012b. *New York & New Jersey Harbor (50 ft Deepening) Navigation Project as of February 2012. Fact Sheet.* Available online at: http://www.nan.usace.army.mil/Portals/37/docs/harbor/Harborfact/nynj%2050.pdf.

USEPA. 1989. *Risk Assessment Guidance for Superfund. Volume I Human Health Evaluation Manual (Part A).* Interim Final. EPA/540/1-89/002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington D.C. December.

USEPA. 1990.The Application of the Amphipod 10-Day Sediment Toxicity Test for Dredged Material Evaluation. Prepared by U.S. Environmental Protection Agency, Environmental Research Laboratory, Narragansett, Rhode Island. Prepared for U.S. Environmental Protection Agency, Region II, New York, New York.

USEPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final. EPA/540/R-97/OCS. U.S. Environmental Protection Agency. June.

USEPA. 1998. *Sediment Quality of the NY/NJ Harbor System.* EPA/902/R-98/001. U.S. Environmental Protection Agency, Regional Environmental Monitoring and Assessment Program (REMAP), Edison, NJ.

USEPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Appendix H: Toxicological Profiles.* August.

USEPA. 2000a. *Phase 2 Report: Further Site Characterization and Analysis, Volume 2F - Revised Human Health Risk Assessment, Hudson River PCBs, Reassessment RI/FS.* Prepared for USEPA Region 2 and US Army Corps of Engineers Kansas City District by TAMS Consultants, Inc. Gradient Corporation. Book 1 of 1, Upper Hudson River, Mid-Hudson River. Nov.

USEPA. 2000b. *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures.* USEPA/630/R-00/002. Risk Assessment Forum, Washington, DC.

USEPA. 2001a. *Risk Assessment Guidance for Superfund (RAGS). Volume I Human Health Evaluation Manual. Part D.* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. Washington D.C.

USEPA. 2001b. *Risk Assessment Guidance for Superfund (RAGS). Volume III Part A. Process for Conducting Probabilistic Risk Assessment.* Superfund. U.S. Environmental Protection Agency, Washington D.C.

USEPA. 2002. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites.* EPA 540-R-01-003. OSWER 9285.7-41. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

USEPA. 2003a. *Sediment Quality of the NY/NJ Harbor System: A 5-Year Revisit (1993/1994– 1998).* EPA/902-R-03-002. U.S. Environmental Protection Agency, Region II, Edison, New Jersey.

USEPA. 2003b. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures.* EPA-600-R-02-013. Office of Research and Development. November.

USEPA. 2003c. *Region 5 RCRA Ecological Screening Levels.* August 22. Available online at: http://epa.gov/region05/waste/cars/pdfs/ecological-screening-levels-200308.pdf.

USEPA. 2004. *Administrative Order on Consent for Remedial Investigation and Feasibility Study, Newark Bay Study Area, USEPA Index No. CERCLA-02-2004-2010.* Including all attachments, amendments, and updates.

USEPA. 2005a. *Guidelines for Carcinogen Risk Assessment.* Risk Assessment Forum. EPA/630/P-03/001F. March.

USEPA. 2005b. *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens.* EPA/630/R-03/003F. March.

USEPA. 2005c. *Human Health Risk Assessment: GE/Housatonic River Site, Rest of River, Volume IV, Appendix C. Consumption of Fish and Waterfowl.* Risk Assessment, Environmental Remediation Contract, GE/Housatonic River Project Pittsfield, MA. DCN: GE-021105-ACMT Contract No. DACW33-00-D-0006, Task Order 0003. Prepared for the US Army Corps of Engineers & USEPA by Weston Solutions. Feb.

USEPA. 2006a. *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000.* National Center for Environmental Assessment Office of Research and Development. November.

USEPA. 2006b*. Newark Bay Study Area Pathways Analysis Report.* Submitted to USEPA Region 2 and USACE Kansas City District. Prepared by Battelle, under contract to Malcolm Pirnie, Inc. May.

USEPA. 2006c. *Region 3 BTAG. Marine Sediment Screening Benchmarks.* July.

USEPA. 2006d. *Region 3 BTAG. Freshwater Sediment Screening Benchmarks*. August.

USEPA. 2007. *Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs).* Interim Final. OSWER Directive 9285.7-78. Office of Solid Waste and Emergency Response. June.

USEPA. 2008a. *Screening-Level Ecological Risk Assessment for Newark Bay Study Area.* Submitted to USEPA Region 2 and USACE Kansas City District. Prepared by Battelle under contract to Malcolm Pirnie, Inc. December 15.

USEPA. 2008b. *Framework for Application of the Toxicity Equivalent Methodology for Polychlorinated Dioxins, Furans, and Biphenyls in Ecological Risk Assessment.* EPA/100/R-08-004. June.

USEPA. 2010a. Memorandum from James E. Woolford to Superfund National Program Managers, Regions 1-10 Re: *Considering Reasonably Anticipated Future Land Use and Reducing Barriers to Reuse at EPA-lead Superfund Remedial Sites*. OSWER Directive 9355.7-19. March 17.

USEPA. 2010b. *Overview of All Chemical Action Plans.* Accessed June 14, 2010. Available online at: http://www.epa.gov/oppt/existingchemicals/pubs/overview.html.

USEPA. 2010c. *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo*-p-*Dioxin and Dioxin-Like Compounds.* EPA/100/R. December.

USEPA. 2011a. *Newark Bay - Comments on the Interim Conceptual Site Model.* June 13.

USEPA. 2011b. *Exposure Factors Handbook 2011 Edition.* Final. EPA/600/R-09/052F. U.S. Environmental Protection Agency, Washington, DC.

USEPA. 2012. *EPA MyWATERS Mapper. Hydrologic Unit Code (HUC8) 02030103.* Available online at: http://watersgeo.epa.gov/mwm/?layer=LEGACY_WBD&feature=02030103&extraLayers=null.

USFWS. 1997. *Significant Habitats and Habitat Complexes of the New York Bight Watershed*. CD ROM. U.S. Fish and Wildlife Service, Southern New England-New York Bight Coastal Ecosystems Program, Charlestown, Rhode Island.

USFWS. 2000*. Impacts of Dioxins, Furans, and Polychlorinated Biphenyls on Anadromous Fish and Piscivorous Birds in Newark Bay.* Pre Assessment Study for the Diamond Alkali Superfund Site, Newark, Essex County, New Jersey.

USGS. 2010. *Organic Compounds and Cadmium in the Tributaries to the Elizabeth River in New Jersey, October 2008 to November 2008: Phase II of the New Jersey Toxics Reduction Workplan for New York-New Jersey Harbor.* Prepared in Cooperation with the New Jersey Department of Environmental Protection. Scientific Investigations Report 2010-5204.

USGS. 2012. Surface-Water Daily Statistics for the Nation: USGS 01389500 Passaic River at Little Falls NJ. Available online at: http://waterdata.usgs.gov/nwis/dvstat?referred_module=sw&search_site_no=01389500&format=sites_selection_links.

Wakeman, T.H. 2006. *Effect of Changes in Sediment and Contaminant Loads in Newark Bay on Future Disposal of Dredged Sediments.* Dissertation. Columbia University, New York, NY.

Walsh J., V. Elia, R. Kane, and T. Halliwell. 1999. *Birds of New Jersey.* New Jersey Audubon Society. Bernardsville, New Jersey.

Wenning, R.J., L. Martello, and A. Prusak-Daniel. 2011. Dioxins, PCBs, and PBDEs in aquatic organisms. In: *Environmental Contaminants in Biota, Interpreting Tissue Concentrations.* 2nd Edition. Edited by W.N. Beyer and J.P. Meador. CRC Press, Boca Raton, FL.

Windward/AECOM. 2009. *LPRSA Human Health and Ecological Risk Assessment Streamlined 2009 Problem Formulation Final.* Prepared for the Cooperating Parties Group. July 31.

Windward. 2011. *Lower Passaic River Restoration Project, Avian Community Survey Data Report for the Lower Passaic River Study Area Summer and Fall 2010.* Prepared for the Cooperating Parties Group.

Windward. 2012. *Revised Risk Analysis and Risk Characterization Plan for the Lower Passaic River Study Area.* Draft. Prepared for Cooperating Parties Group by Windward Environmental, LLC and AECOM. April 13.

Wintermyer, M. and K. Cooper. 2003. Dioxin/furan and polychlorinated biphenyl concentrations in eastern oysters (*Crassostrea virginica Gmelin*) tissues and the effects on egg fertilization and development. Journal of Shellfish Research 22:737-746.

Wirgin, I. 2004. *Resistance of Atlantic tomcod from the Hudson River to PCBs and TCDD, but not PAHs.* A PowerPoint presentation given at the SBRP Annual Meeting, Seattle, WA. November.

Wirgin, I. and R.C. Chambers. 2006. Atlantic tomcod (*Microgadus tomcod*): a model species for the responses of Hudson River fish to toxicants. *Am Fish Soc Sym* 51:331-365.

WHO. 1989. *DDT and its Derivatives – Environmental Aspects.* Environmental Health Criteria 83. Geneva, Switzerland: World Health Organization.

WHO. 2001. *Zinc.* Environmental Health Criteria 221. Geneva, Switzerland: World Health Organization. Available online at: http://www.who.int/ipcs/publications/ehc/ehc_221/en/index.html.

Wood, R. 1995. Diamondback Terrapin. In: *Living Resources of the Delaware Estuary. Delaware Estuary Program.* Edited by L.E. Dove and R.M. Nyman., pp. 299-304. As cited in USACE (1997).

Woodhead, P.M.J. 1991. *Inventory and Characterization of Habitat and Fish Resources and Assessment of Information on Toxic Effects of the New York-New Jersey Harbor Estuary.* A Report to the NY/NJ Harbor Estuary Program. Marine Sciences Research Center, Stony Brook, New York. May.

Yuan, Z., M. Wirgin, S. Courtenay, M. Ikonomou, and I. Wirgin. 2001. Is Hepatic Cytochrome P4501A1 Expression Predictive of Hepatic Burdens of Dioxins, Furans, and PCBs in Atlantic Tomcod from the Hudson River Estuary? Aquatic Toxicology 54(3-4):217-230.

Tables

Table 3-1
Annual Ichthyoplankton Catch in Newark Bay (1999-2006)

Species	Annual Ichthyoplankton Catch								Total Number Caught
	1999	2000	2001	2002	2003	2004	2005	2006	
Acipenser sp.									
Larvae	–	–	–	–	–	–	–	1	1
Alosa sp.									
Egg	–	–	1	–	–	–	–	–	1
Larvae	–	–	2	–	–	–	–	–	2
American sandlance									
Larvae	–	–	9	1	2	1	1	–	14
American shad									
Larvae	–	–	–	–	–	–	39	–	39
Atlantic cod									
Larvae	–	–	–	–	–	1	–	–	1
Atlantic croaker									
Juvenile	–	–	–	–	1	–	1	18	20
Larvae	–	–	–	–	5	1	13	13	32
Atlantic herring									
Juvenile	–	–	–	–	–	1	–	–	1
Larvae	6	–	5	–	9	8	–	2	30
Atlantic mackerel									
Larvae	–	–	–	–	1	–	–	–	1
Atlantic menhaden									
UID	–	–	–	–	–	–	59	2	61
Egg	39	–	9	85	105	469	1311	44	2062
Larvae	257	1	2	7	61	100	172	9	609
Atlantic silverside									
Larvae	–	–	–	2	3	1	1	–	7
Atlantic tomcod									
Juvenile	–	–	5	–	1	3	4	–	13
Larvae	–	–	11	–	1	20	31	–	63
Bay anchovy									
Egg	705	–	144	2431	66	19068	30112	849	53375
Juvenile	–	1	–	–	1	–	1	–	3
Larvae	37	1	2	721	589	1929	525	110	3914
Blennidae									
Larvae	–	–	1	2	–	–	–	–	3
Butterfish									
Larvae	–	–	–	1	–	–	–	–	1
Clupeid unidentified									
Larvae	–	–	16	362	10	–	–	–	388
Conger eel (unidentified)	–	–	1	–	–	–	–	–	1
Cunner									
Larvae	–	–	–	2	–	–	5	–	7
Fourbeard rockling									
Egg	28	–	9	1	1	–	19	5	63

Table 3-1
Annual Ichthyoplankton Catch in Newark Bay (1999-2006)

Species	Annual Ichthyoplankton Catch								Total Number Caught
	1999	2000	2001	2002	2003	2004	2005	2006	
Fourspot flounder									
Egg	73	–	–	–	–	–	–	–	73
Larvae	–	–	–	–	1	–	–	–	1
Gadid unidentified									
Egg	–	–	–	–	–	1	39	3	43
Larvae	–	–	–	–	–	–	2	–	2
Gobiid unidentified									
Larvae	6	–	–	1208	44	29	158	496	1941
Goosefish									
Larvae	–	–	–	1	–	–	–	–	1
Grubby									
UID	–	–	–	–	–	4	3	–	7
Juvenile	–	–	–	–	–	2	–	–	2
Larvae	–	–	478	244	35	430	358	81	1626
Hogchocker									
Larvae	–	–	–	–	–	–	1	–	1
Egg	55	–	2	25	–	–	–	–	82
Labridae									
Egg	350	–	680	391	24	886	1640	90	4061
Longhorn sculpin									
Larvae	–	–	–	–	–	3	–	–	3
Myoxocephalus sp.									
Larvae	68	–	–	–	–	–	–	–	68
Northern pipefish									
Juvenile	2	–	–	6	1	–	–	–	9
Larvae	8	–	8	92	10	13	62	20	213
Northern puffer									
Larvae	–	–	–	–	–	–	1	–	1
Prionotus sp.									
Larvae	–	–	–	–	–	–	1	–	1
Egg	–	–	–	–	6	–	132	10	148
Rock gunnel									
Larvae	–	–	4	11	1	4	5	1	26
Spot									
Larvae	–	–	–	2	–	–	–	–	2
Striped bass									
Larvae	–	–	1	–	1	–	–	–	2
Striped cuskeel									
Larvae	–	–	1	–	–	–	–	–	1
Summer flounder									
Larvae	–	6	6	1	–	–	–	–	13
Tautog									
Larvae	–	–	–	2	–	3	29	0	34

Table 3-1
Annual Ichthyoplankton Catch in Newark Bay (1999-2006)

Species	Annual Ichthyoplankton Catch								Total Number Caught
	1999	2000	2001	2002	2003	2004	2005	2006	
Unidentified									
UID	–	–	–	–	–	1	1	–	2
Egg	–	–	–	1	–	–	–	–	1
Larvae	6	–	–	34	16	350	–	–	406
Walleye									
Larvae	–	–	–	–	–	–	–	2	2
Weakfish									
Egg	870	–	52	108	4	25	5884	2	6945
Juvenile	–	–	1	–	–	–	1	–	2
Larvae	9	9	–	72	7	28	114	–	239
White perch									
Larvae	–	–	–	–	13	–	–	–	13
Windowpane									
Egg	–	–	396	551	77	256	13	–	1293
Juvenile	–	–	1	1	3	–	–	–	5
Larvae	35	–	21	10	6	4	37	5	118
Winter flounder									
UID	–	–	–	–	–	4	13	–	17
Egg	15	–	–	6	1	1	4	–	27
Juvenile	–	–	–	–	2	–	1	–	3
Larvae	34	–	230	537	626	721	198	97	2443

Notes:
2007, 2008, and 2009 data are given in density only and are, therefore, not included.

Acronyms and Abbreviations:
UID = unidentified
USACE = U.S. Army Corps of Engineers

Source:
USACE. 2003. *Aquatic Biological Sampling Program 1998–2003.* Raw data in Access database. New York and New Jersey Harbor Navigation Project. U.S. Army Corps of Engineers, New York District, New York, New York. August.

USACE. 2004, 2005, and 2006. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

Table 3-2
Dominant Benthic Invertebrate Species in Newark Bay

Sampling Program	NOAA May 1993 to April 1994[a]	REMAP Summer 1993/94[b]	USACE June 1995[c]	USACE October 1995[c]	USACE Monthly 1995/96[d]	REMAP Summer 1998/99[b]
Number of Stations	**25**	**28**	**10**	**10**	**5**	**29**
Taxa - Scientific Name	**Dominant Species**	**Species Count**				
Polychaeta						
Cirratulidae	–	–	2	–	–	–
Glycera americana	–	–	–	9	–	–
Glycera spp.	–	–	–	–	9	–
Heteromastus filiformis	–	9	6	–	–	–
Leitoscoloplos fragilis	–	–	8	–	–	–
Leitoscoloplos robustus	✓	4	–	7	–	8
Leitoscoloplos sp.	–	5	3	–	–	–
Marenzelleria viridis	–	–	5	–	–	–
Mediomastus sp.	–	–	–	–	–	2
Mediomastus ambiseta	✓	6	4	2	–	–
Paraonidae	–	–	–	–	4	–
Pectinaria gouldii	–	–	–	5	–	–
Phyllodocidae	–	–	10	–	8	–
*Polydora cornuta**	✓	–	–	10	–	3
Polydora ligni	–	–	–		10	–
Sabellaria vulgaris	✓	–	–	6	–	–
Scoloplos sp.	–	–	–	–	1	–
*Streblospio benedicti**	✓	1	1	3	2	1
Tharyx sp. A	✓	7	9	–	–	–
Oligochaeta						
*Oligochaeta**	✓	2	7	8	–	4
Mollusca						
Bivalvia	–	–	–	4	–	–
Odostomia sp.	✓	–	–	–	–	–
*Mulinia lateralis**		10	–	1	3	9
Mya arenaria	✓	–		–	6	–
Mytilus edulis	–	–	–	–	–	6
Rictaxis punctostriatus	–	–	–	–	–	10

Table 3-2
Dominant Benthic Invertebrate Species in Newark Bay

Sampling Program	NOAA May 1993 to April 1994[a]	REMAP Summer 1993/94[b]	USACE June 1995[c]	USACE October 1995[c]	USACE Monthly 1995/96[d]	REMAP Summer 1998/99[b]
Number of Stations	**25**	**28**	**10**	**10**	**5**	**29**
Taxa - Scientific Name	**Dominant Species**	**Species Count**				
Crustacea						
Ampelisca abdita	–	–	–	–	–	7
Corophium tuberculatum	–	–	–	–	–	5
Cyathura polita	–	–	–	–	5	–
Gammarus daiberi	–	3	–	–	–	–
Leucon americanus	✓	8	–	–	–	–
Oxyurostylis smithi	–	–	–	–	7	–

Notes:
* Indicates pollution indicative species (USEPA 2003b).
✓ indicates dominant species (NOAA 1994).

Acronyms and Abbreviations:
NOAA = National Oceanic and Atmospheric Administration
REMAP = Regional Environmental Monitoring and Assessment Program
USACE = U.S. Army Corps of Engineers
USEPA = U.S. Environmental Protection Agency

Sources:
a. NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.
b. USEPA. 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures.* EPA-600-R-02-013. Office of Research and Development. November.
c. Iocco, L.E., P. Wilber, R.J. Diaz, D.G. Clarke, and R.J. Will. 2000. *Final Report. Benthic Habitats of New York/New Jersey Harbor: 1995 Survey of Jamaica, Upper, Newark, Bowery, and Flushing Bays.* National Oceanic and Atmospheric Administration, Virginia Institute of Marine Sciences, and U.S. Army Corps of Engineers.
d. USACE. 1997. *Final Environmental Impact Statement on the Newark Bay Confined Disposal Facility.* U.S. Army Corps of Engineers, New York District, New York, New York. April.
USACE. 1999. Draft Feasibility Report for New York and New Jersey Harbor Investigation Study. Draft Environmental Impact Statement (DEIS). U.S. Army Corps of Engineers, New York District, New York, New York.

Table 3-3
Essential Fish Habitat Designations by Life Stage for Newark Bay

Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Red hake (*Urophycis chuss*)	✓	✓	✓	✓	–
Winter flounder (*Pseudopluronectes americanus*)	✓	✓	✓	✓	✓
Windowpane flounder (*Scopthalmus aquosus*)	✓	✓	✓	✓	✓
American plaice (*Hippoglossoides platessoides*)	–	✓	✓	✓	–
Atlantic sea herring (*Clupea harengus*)	–	✓	✓	✓	–
Bluefish (*Pomatomus saltatrix*)	✓	✓	✓	✓	–
Atlantic butterfish (*Peprilus triacanthus*)	–	✓	✓	✓	–
Atlantic mackerel (*Scomber scombrus*)	–	–	✓	✓	–
Summer flounder (*Paralichthys dentatus*)	–	✓	✓	✓	–
Scup (*Stenotomus chrysops*)	✓	✓	✓	✓	–
Black sea bass (*Centropristus striata*)	–	–	✓	✓	–
King mackerel (*Scomberomorus cavalla*)	✓	✓	✓	✓	–
Spanish mackerel (*Scomberomorus maculates*)	✓	✓	✓	✓	–
Atlantic mackerel (*Scomber scombrus*)	–	–	✓	✓	–
Cobia (*Rachycentron canadum*)	✓	✓	✓	✓	–
Dusky shark (*Carcharhinus obscurus*)	–	✓	✓	–	–
Sand tiger shark (*Carcharias taurus*)	–	✓	✓	–	–
Sandbar shark (*Carcharhinus plumbeus*)	–	✓	✓		–
Clearnose skate (*Raja eglanteria*)	–	–	✓	✓	–
Little skate (*Raja erinacea*)	–	–	✓	✓	–
Winter skate (*Leucoraja ocellata*)	–	–	✓	✓	–

Notes:
✓ indicates habitat is suitable for lifestage.
– indicates habitat is not suitable for lifestage.

Acronyms and Abbreviations:
USACE = U.S. Army Corps of Engineers

Sources:
USACE. 2004. Essential Fish Habitat Assessment. New York and New Jersey Harbor Deepening Project. U.S. Army Corps of Engineers, New York District, New York, New York.
USACE. Undated. Essential Fish Habitat Assessment for Newark Bay Maintenance Dredging: Newark Bay – Port Newark Channel, Port Newark Pierhead Channel, and Port Elizabeth Channel of Newark Bay, Hackensack and Passaic Rivers Federal Navigation Project. Prepared by USACE, New York, New York. 26 pp.

Table 3-4
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2009)

		January											February												
Common Name	**Scientific Name**	**Jan-94**	**Jan-96**	**Jan-02**	**Jan-03**	**Jan-04**	**Jan-05**	**Jan-06**	**Jan-07**	**Jan-09**	**Average**	**Average % Comp**	**Feb-94**	**Feb-96**	**Feb-99**	**Feb-02**	**Feb-03**	**Feb-04**	**Feb-05**	**Feb-06**	**Feb-07**	**Feb-08**	**Feb-09**	**Average**	**Average % Comp**
White perch	*Morone americana*	244	0	591	613	119	121	889	743	189	390	61.5	738	0	131	634	55	219	8	648	985	0	6	311	54.7
Striped bass	*Morone saxatillis*	215	0	355	147	69	28	179	35	10	115	18.2	1021	2	24	362	12	281	2	289	169	0	117	207	36.4
Bay anchovy	*Anchoa mitchilli*	0	0	2	5	0	31	0	5	2	5	0.8	0	0	0	0	0	0	0	2	0	1	0	0	0.0
Atlantic herring	*Clupea harengus*	0	0	0	0	0	1	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic tomcod	*Microgadus tomcod*	9	0	0	0	1	0	0	0	0	1	0.2	8	0	0	0	0	2	0	0	0	0	0	1	0.2
Weakfish	*Cynoscion regalis*	0	0	0	0	0	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Spotted hake	*Urophycis regla*	0	0	10	2	0	2	1	96	0	12	1.9	0	0	0	33	1	0	0	1	0	0	0	3	0.6
Winter flounder	*Pleuronectes americanus*	52	0	45	37	14	3	11	14	5	20	3.2	33	2	0	38	6	48	1	15	0	0	20	15	2.6
Alewife	*Alosa pseudoharengus*	9	0	22	6	1	0	0	1	1	4	0.7	0	0	0	22	0	1	0	7	0	0	1	3	0.5
Blueback herring	*Alosa aestivalls*	0	0	13	2	0	0	6	10	5	4	0.6	0	0	0	44	0	5	0	27	0	0	0	7	1.2
Atlantic menhaden	*Brevooria tyrannus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Rainbow smelt	*Osmerus mordax*	313	0		0	0	0	0	0	1	39	6.2	25	0	0	0	0	0	0	0	0	0	0	2	0.4
Atlantic silverside	*Menidia menidia*	1	0	0	21	1	7	0	45	4	9	1.4	0	0	0	12	0	3	2	25	2	18	7	6	1.1
Gizzard shad	*Dorosoma cepedianum*	47	1	6	2	8.1	4	7	18	1	10	1.7	1	0	0	1	0	1	0	1	4	0	0	1	0.1
Summer flounder	*Paralichthys dentatus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Grubby	*Myoxecephalus aenaeus*	66	0	2	0	1	0	0	0	0	8	1.2	44	0	0	0	0	4	0	0	0	0	17	6	1.0
Red hake	*Urophycis chuss*	3	0	0		4	0	4	25	2	5	0.7	0	0	0	0	1	0	0	3	7	0	0	1	0.2
Windowpane	*Scophthalmus aquosus*	1	0	14	0	2	2	0	2	0	2	0.4	2	0	0	18	1	0	0	0	1	0	0	2	0.4
Butterfish	*Peprillus tracanthus*	0	0	0	0	0	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Bluefish	*Pomatomus saltatrix*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
American shad	*Alosa sapidissima*	0	0	5	0	0	0	0	0	0	1	0.1	0	0	0	6	0	0	0	0	1	0	2	1	0.1
Striped searobin	*Prionotus evolans*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic croaker	*Micropogonia undulatus*	0		0	1	0	39	1	0	0	5	0.8	0	0	0	0	0	0	0	7	0	0	0	1	0.1
Smallmouth flounder	*Etropus microstomus*	0	0	4	0	0	0	0	1	0	1	0.1	0	0	0	1	0	0	0	0	0	0	0	0	0.0
Northern searobin	*Prionotus carollnus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silver perch	*Bairdiella chrysura*	0	0	0	0	0	0	19	0	0	2	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern pipefish	*Syngnathus fuscus*	0	0	1	1	0	0	0	0	1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Scup	*Stenotomus chrysops*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silver hake	*Merluccius bilinearis*	0	0	0	1	2	0	0	1	0	0	0.1	0	0	0	0	0	2	0	0	1	0	0	0	0.0
Hogchoker	*Trinectes maculatus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silverside	Atherinidae (unidentified)	0	0	24	0	0	0	0	0	0	3	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Threespine stickleback	*Gasterosteus aculeatus*	1	0	0	0	0	1	0	0	0	0	0.0	6	0	0	0	0	0	0	0	0	0	0	1	0.1
American eel	*Anguilla rostrata*	2	0	1	0	0	0	0	1	0	0	0.1	1	0	0	0	0	0	0	0	0	0	0	0	0.0
Cunner	*Tautogolabrus adspersus*	1	0	1	1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Tautog	*Tautoga onitis*	0	0	0	0	0	0	1	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern kingfish	*Menticirrhus saxatillis*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Spot	*Leiostomus santhurus*	0	0	0	0	0	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Crevalle Jack	*Caranx hippos*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Black sea bass	*Centropristis striata*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Herring	Clupeidae (unidentified)	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern puffer	*Sphaeroldes maculatus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Rock gunnel	*Pholis gunnellus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Striped killifish	*Fundulus majalis*	1	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	1	1	0	0	0	0	0	0	0.0
Little skate	*Raja erinacea*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Naked goby	*Gobiosoma bosc*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Fourspot flounder	*Paralichthys oblongus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0.0
Lookdown	*Selene vomer*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Oyster toadfish	*Opsanus tau*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Seaboard Goby	*Gobiosoma ginsburgi*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Mummichog	*Fundulus heteroclitus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	1.7	0	0	0	0	0	0	0.0
American sandlance	*Ammodytes americanus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic sturgeon	*Acipenser oxyrhynchus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Chub mackerel	*Scomber japonicus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Clearnose skate	*Raja eglanteria*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0.0
Conger eel	*Conger oceanicus*	1	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Goby	*Gobiidee sp.*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Lined seahorse	*Hippocampus erectus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern stargazer	*Astroscopus guttatus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Planehead filefish	*Monacanthus hispidus*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Striped cuskeel	*Ophidion marginatum*	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0.0
	TOTALS	**966**	**1**	**1096**	**839**	**223**	**239**	**1118**	**1000**	**221**			**1880**	**4**	**155**	**1174**	**77**	**569**	**13**	**1025**	**1170**	**19**	**170**		
	Monthly Average									**634**													**569**		

Notes:
Based on catch per unit effort (CPUE).

Acronyms and Abbreviations:
LMS = Lawler, Matusky and Skelly Engineers, Inc.
NOAA = National Oceanic and Atmospheric Administration
USACE = U.S. Army Corps of Engineers

Sources:
USACE. 2004, 2005, 2006, 2007, 2008, and 2009. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.
NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.
LMS. 1996. *Biological Survey of Newark Bay Shoal Areas and Adjacent Kill Van Kull and Arthur Kill Channels.* Lawler, Matusky and Skelly Engineers, Inc. Prepared for the Port Authority of New York and New Jersey.

Table 3-4
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2009)

		March													April												
Common Name	**Scientific Name**	**Mar-94**	**Mar-96**	**Mar-99**	**Mar-02**	**Mar-03**	**Mar-04**	**Mar-05**	**Mar-06**	**Mar-07**	**Mar-08**	**Mar-09**	**Average**	**Average % Comp**	**Apr-94**	**Apr-95**	**Apr-99**	**Apr-02**	**Apr-03**	**Apr-04**	**Apr-05**	**Apr-06**	**Apr-07**	**Apr-08**	**Apr-09**	**Average**	**Average % Comp**
White perch	*Morone americana*	669	0	326	24	6	726	80	172	269	0	248	229	39.1	355	1	0	0	49	191	1	0	1	0	2	55	14.8
Striped bass	*Morone saxatillis*	1844	0	234	27	21	866	1	63	18	0	16	281	47.9	1009	17	38	63	57	110	24	1	1	1	31	123	33.3
Bay anchovy	*Anchoa mitchilli*	0	0	0	1	0	0	0	1	0	0	0	0	0.0	1	0	0	1	0	0	0	1	0	0	0	0	0.1
Atlantic herring	*Clupea harengus*	1	0	0	1	0	0	1	0	0	0	0	0	0.0	7	0	0	19	33	12	4	175	0	72	0	29	7.9
Atlantic tomcod	*Microgadus tomcod*	7	0	0	0	0	35	0	0	0	0	0	4	0.7	102	0	0	0	0	19	0	0	0	0	0	11	3.0
Weakfish	*Cynoscion regalis*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Spotted hake	*Urophycis regla*	0	0	14	34	0	5	0	15	0	0	0	6	1.1	26	0	300	211	95	103	1	7	8	0	11	69	18.8
Winter flounder	*Pleuronectes americanus*	57	3	242	22	8	20	11	6	5	0	3	34	5.8	72	8	100	27	11	29	5	0	0	1	5	24	6.4
Alewife	*Alosa pseudoharengus*	0	0	0	6	0	17	1	10	6	1	27	6	1.1	9	0	1	3	2	129	10	10	1	0	116	26	6.9
Blueback herring	*Alosa aestivalls*	0	0	0	31	0	45	2	0	2	0	1	7	1.3	1	0	0	3	1	62	0	105	1	0	1	16	4.3
Atlantic menhaden	*Brevooria tyrannus*	0	0	0	1	0	0	0	0	0	0	0	0	0.0	2	0	0	0	0	0	0	0	0	1	0	0	0.1
Rainbow smelt	*Osmerus mordax*	28	0	0	0	0	0	0	0	0	0	0	3	0.4	2	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic silverside	*Menidia menidia*	2	0	0	0	0	9	2	13	2	0	0	3	0.4	0	0	0	0	0	2	0	0	0	0	2	0	0.1
Gizzard shad	*Dorosoma cepedianum*	0	0	1	1	0	0	0	2	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Summer flounder	*Paralichthys dentatus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	8	0	0	1	2	1	0	0	0	0	0	1	0.3
Grubby	*Myoxecephalus aenaeus*	54	0	7	0	0	1	0	0	0	0	0	6	1.0	13	0	1	2	0	2	0	0	0	0	0	2	0.5
Red hake	*Urophycis chuss*	1	0	0	1	0	2	1	4	0	0	1	1	0.2	3	0	0	0	1	9	0	0	0	0	4	2	0.4
Windowpane	*Scophthalmus aquosus*	4	0	2	3	0	0	0	0	0	0	0	1	0.1	10	0	1	9	1	4	0	0	0	0	1	2	0.6
Butterfish	*Peprillus tracanthus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Bluefish	*Pomatomus saltatrix*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
American shad	*Alosa sapidissima*	0	0	0	0	1	19	1	1	1	0	2	2	0.4	3	0	0	0	0	10	4	3	0	0	0	2	0.5
Striped searobin	*Prionotus evolans*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	1	0	0	0	0	0	0	0	0	0	0.0
Atlantic croaker	*Micropogonia undulatus*	0	0	0	0	0	0	0	1	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Smallmouth flounder	*Etropus microstomus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	3	35	0	0	0	0	0	1	4	1.0
Northern searobin	*Prionotus carollnus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silver perch	*Bairdiella chrysura*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern pipefish	*Syngnathus fuscus*	0	0	0	1	0	0	0	0	0	0	0	0	0.0	2	0	2	1	0	1	1	2	0	0	2	1	0.3
Scup	*Stenotomus chrysops*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silver hake	*Merluccius bilinearis*	0	0	4	0	0	0	0	3	0	0	0	1	0.1	0	0	15	0	0	1	0	0	0	0	0	1	0.4
Hogchoker	*Trinectes maculatus*	1	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0	0	0	0	0.0
Silverside	Atherinidae (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Threespine stickleback	*Gasterosteus aculeatus*	13	0	0	0	0	0	0	0	0	0	1	1	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.0
American eel	*Anguilla rostrata*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	1	0	0	0	0	0	0	0	0.0
Cunner	*Tautogolabrus adspersus*	2	0	1	2	0	0	0	0	0	0	0	0	0.1	2	0	0	0	1	0	0	0	0	0	0	0	0.1
Tautog	*Tautoga onitis*	0	0	0	0	0	0	0	0	0	0	1	0	0.0	1	0	0	1	0	0	0	0	0	0	0	0	0.0
Northern kingfish	*Menticirrhus saxatillis*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Spot	*Leiostomus santhurus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Crevalle Jack	*Caranx hippos*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Black sea bass	*Centropristis striata*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	1	0	0	0	0	0	0	0	0.0
Herring	Clupeidae (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	2	0	0	0	0	0	0	0	0	0.0
Northern puffer	*Sphaeroldes maculatus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	1	0	0	0	0	0	0	0	0.0
Rock gunnel	*Pholis gunnellus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	2	0	0	0	0	0	0	0	0	0.1
Striped killifish	*Fundulus majalis*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Little skate	*Raja erinacea*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	1	0	0	0	0	0	0	0	0	0	0.0
Naked goby	*Gobiosoma bosc*	0	0	0	1	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Fourspot flounder	*Paralichthys oblongus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Lookdown	*Selene vomer*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Oyster toadfish	*Opsanus tau*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Seaboard Goby	*Gobiosoma ginsburgi*	0	0	0	0	0	0	1	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Mummichog	*Fundulus heteroclitus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
American sandlance	*Ammodytes americanus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic sturgeon	*Acipenser oxyrhynchus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Chub mackerel	*Scomber japonicus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Clearnose skate	*Raja eglanteria*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Conger eel	*Conger oceanicus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Goby	*Gobiidee sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Lined seahorse	*Hippocampus erectus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern stargazer	*Astroscopus guttatus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Planehead filefish	*Monacanthus hispidus*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Striped cuskeel	*Ophidion marginatum*	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	TOTALS	**2683**	**3**	**831**	**156**	**36**	**1744**	**101**	**291**	**304**	**1**	**300**			**1633**	**25**	**460**	**349**	**291**	**686**	**50**	**304**	**12**	**76**	**177**		
	Monthly Average											**586**													**369**		

Notes:
Based on catch per unit effort (CPUE).

Acronyms and Abbreviations:
LMS = Lawler, Matusky and Skelly Engineers, Inc.
NOAA = National Oceanic and Atmospheric Administration
USACE = U.S. Army Corps of Engineers

Sources:
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NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.
LMS. 1996. *Biological Survey of Newark Bay Shoal Areas and Adjacent Kill Van Kull and Arthur Kill Channels.* Lawler, Matusky and Skelly Engineers, Inc. Prepared for the Port Authority of New York and New Jersey.

Table 3-4
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2009)

		May												June										
Common Name	**Scientific Name**	**May-93**	**May-95**	**May-02**	**May-03**	**May-04**	**May-05**	**May-06**	**May-07**	**May-08**	**May-09**	**Average**	**Average % Comp**	**Jun-93**	**Jun-95**	**Jun-99**	**Jun-02**	**Jun-03**	**Jun-04**	**Jun-05**	**Jun-06**	**Jun-07**	**Average**	**Average % Comp**
White perch	*Morone americana*	4	0	0	2	1	0	0	0	0	0	1	0.1	2	0	1	0	0	0	0	0	0	0	0.1
Striped bass	*Morone saxatilis*	64	40	13	11	10.7	1	0	8.7	4	0	15	1.5	82	64	1	17	7	5	0	0	1.4	20	3.3
Bay anchovy	*Anchoa mitchilli*	1	4	34	852	72	3	1385	184	87	789	341	34.6	95	24	0	39	35	785	137	558	610	254	42.2
Atlantic herring	*Clupea harengus*	50	4	1	17	253	213	301	0	25	3356	422	42.8	619	0	0	0	1	0	0	0	0	69	11.4
Atlantic tomcod	*Microgadus tomcod*	215	1	0	6	74	9	0	1	7	0	31	3.2	1098	0	1	0	27	13	0	0	2	127	21.1
Weakfish	*Cynoscion regalis*	11	1	1	0	0	0	0	0	0	0	1	0.1	20	0	0	1	0	1	0	0	0	2	0.4
Spotted hake	*Urophycis regla*	288	2	143	198	45	26	150	0	3	16	87	8.8	452	0	10	55	88	2	0	17	9	70	11.7
Winter flounder	*Pleuronectes americanus*	42	6	13	5	3.7	10	1	0	1	2	8	0.9	112	10	19	50	6	5	2	0	3	23	3.8
Alewife	*Alosa pseudoharengus*	17	0	0	3	6	0	19	1	0	25	7	0.7	2	0	0	0	0	1	0	0	0	0	0.1
Blueback herring	*Alosa aestivalis*	44	0	72	1	4	5	7	5	10	130	28	2.8	8	2	0	1	0	0	0	0	0	1	0.2
Atlantic menhaden	*Brevooria tyrannus*	252	0	1	0	0	0	1	0	0	0	25	2.6	25	0	0	6	1	0	0	0	0	4	0.6
Rainbow smelt	*Osmerus mordax*	1	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic silverside	*Menidia menidia*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Gizzard shad	*Dorosoma cepedianum*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	1	0	0.0
Summer flounder	*Paralichthys dentatus*	29	5	10	9	0	2	0	0	1	0	6	0.6	58	6	8	12	5	4	0	0	2	11	1.8
Grubby	*Myoxecephalus aenaeus*	13	0	0	0	0	0	0	0	0	0	1	0.1	28	0	0	2	0	0	0	0	0	3	0.6
Red hake	*Urophycis chuss*	45	0	0	0	0	0	3	0	0	1	5	0.5	33	0	0	0	1	0	0	1	0	4	0.6
Windowpane	*Scophthalmus aquosus*	1	0	1	1	1	0	1	0	0	1	1	0.1	2	0	3	3	3	0	0	0	0	1	0.2
Butterfish	*Peprillus tracanthus*	0	0	0	0	0	1	4	0	0	0	1	0.1	0	0	1	0	0	0	3	3	1	1	0.1
Bluefish	*Pomatomus saltatrix*	8	0	0	0	0	0	0	0	0	0	1	0.1	16	0	0	1	0	10	0	0	0	3	0.5
American shad	*Alosa sapidissima*	4	0	0	0	4	1	6	0	0	0	1	0.1	1	1	0	0	0	1	0	0	0	0	0.1
Striped searobin	*Prionotus evolans*	2	0	1	1	0	0	0	0	0	0	0	0.0	5	0	1	3	0	0	0	0	0	1	0.2
Atlantic croaker	*Micropogonia undulatus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Smallmouth flounder	*Etropus microstomus*	0	0	2	0	0	0	0	0	1	0	0	0.0	0	0	0	4	0	0	0	0	0	0	0.1
Northern searobin	*Prionotus carollnus*	1	0	8	0	0	0	0	0	1	0	1	0.1	9	0	1	10	1	0	0	0	0	2	0.4
Silver perch	*Bairdiella chrysura*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Northern pipefish	*Syngnathus fuscus*	1	1	0	0	1	0	1	2	0	0	1	0.1	3	1	0	3	0	0	0	0	0	1	0.1
Scup	*Stenotomus chrysops*	1	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	1	0	0	0	0	0	0	0.0
Silver hake	*Merluccius bilinearis*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Hogchoker	*Trinectes maculatus*	1	0	1	0	0	0	1	0	0	0	0	0.0	2	0	0	0	0	0	0	4	2	1	0.1
Silverside	Atherinidae (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Threespine stickleback	*Gasterosteus aculeatus*	0	0	0	0	1	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
American eel	*Anguilla rostrata*	1	0	1	0	0	0	1	0	0	0	0	0.0	1	0	3	1	1	0	0	0	0	1	0.1
Cunner	*Tautogolabrus adspersus*	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	1	1	0	0	0	0	0	0.1
Tautog	*Tautoga onitis*	0	0	1	1	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Northern kingfish	*Menticirrhus saxatillis*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Spot	*Leiostomus santhurus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Crevalle Jack	*Caranx hippos*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Black sea bass	*Centropristis striata*	0	0	1	0	0	0	0	0	0	0	0	0.0	0	0	0	2	0	0	0	0	0	0	0.0
Herring	Clupeidae (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	2	0	0	0	0	0	0	0.0
Northern puffer	*Sphaeroldes maculatus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Rock gunnel	*Pholis gunnellus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	1	0	0	0	0.0
Striped killifish	*Fundulus majalis*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Little skate	*Raja erinacea*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Naked goby	*Gobiosoma bosc*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0.0
Fourspot flounder	*Paralichthys oblongus*	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0	0	0.0
Lookdown	*Selene vomer*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Oyster toadfish	*Opsanus tau*	0	0	1	0	0	0	0	0	0	0	0	0.0	0	0	0	0	1	0	0	0	0	0	0.0
Seaboard Goby	*Gobiosoma ginsburgi*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	1	0	0	0	0.0
Mummichog	*Fundulus heteroclitus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
American sandlance	*Ammodytes americanus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic sturgeon	*Acipenser oxyrhynchus*	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0	0	0.0
Chub mackerel	*Scomber japonicus*	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0	0	0.0
Clearnose skate	*Raja eglanteria*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Conger eel	*Conger oceanicus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Goby	*Gobiidee sp.*	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0	0	0.0
Lined seahorse	*Hippocampus erectus*	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0	0	0.0
Northern stargazer	*Astroscopus guttatus*	0	0	0	1	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Planehead filefish	*Monacanthus hispidus*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
Striped cuskeel	*Ophidion marginatum*	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0
	TOTALS	**1096**	**64**	**305**	**1108**	**476**	**271**	**1881**	**202**	**140**	**4320**			**2680**	**108**	**49**	**215**	**178**	**827**	**144**	**583**	**632**		
	Monthly Average										**986**												**602**	

Notes:
Based on catch per unit effort (CPUE).

Acronyms and Abbreviations:
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Sources:
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NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.
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Table 3-4
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2009)

		July				August						September					October					
Common Name	**Scientific Name**	**Jul-93**	**Jul-95**	**Average**	**Average % Comp**	**Aug-93**	**Aug-95**	**Aug-99**	**Aug-06**	**Average**	**Average % Comp**	**Sep-93**	**Sep-95**	**Sep-06**	**Average**	**Average % Comp**	**Oct-93**	**Oct-95**	**Oct-98**	**Oct-06**	**Average**	**Average % Comp**
White perch	*Morone americana*	0	1	1	0.0	0	0	0	0	0	0.0	0	4	0	1	0.1	1	0	0	0	0	0.0
Striped bass	*Morone saxatillis*	348	42	195	14.4	47	0	0	1	16	0.4	36	1	3	13	0.7	80	9	0	5	24	3.3
Bay anchovy	*Anchoa mitchilli*	453	147	300	22.1	409	785	1	12636	398	9.6	758	1700	1994	1484	73.0	2	9	100	338	112	16.0
Atlantic herring	*Clupea harengus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	1	0	0	0	0	0.0
Atlantic tomcod	*Microgadus tomcod*	1226	1	614	45.2	684	0	0	0	228	5.5	15	0	0	5	0.2	91	0	0	0	23	3.2
Weakfish	*Cynoscion regalis*	9	4	7	0.5	808	0	603	2	470	11.3	1128	1	22	384	18.9	740	0	173	35	237	33.7
Spotted hake	*Urophycis regla*	31	4	18	1.3	0	0	0	1	0	0.0	0	0	0	0	0.0	17	0	0	2	5	0.7
Winter flounder	*Pleuronectes americanus*	182	7	95	7.0	285	1	5	2	97	2.3	54	9	2	22	1.1	116	5	1	4	32	4.5
Alewife	*Alosa pseudoharengus*	31	0	16	1.1	4	0	0	0	1	0.0	3	0	0	1	0.0	31	1	1	0	8	1.2
Blueback herring	*Alosa aestivalls*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	1	0	0.0	2	0	0	4	2	0.2
Atlantic menhaden	*Brevooria tyrannus*	83	0	42	3.1	22	0	1	80	8	0.2	2	0	10	4	0.2	30	0	1	724	189	26.8
Rainbow smelt	*Osmerus mordax*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Atlantic silverside	*Menidia menidia*	0	0	0	0.0	0	0	0	0	0	0.0	0	78	0	26	1.3	30	44	0	10	21	3.0
Gizzard shad	*Dorosoma cepedianum*	0	0	0	0.0	2	0	0	0	1	0.0	0	0	0	0	0.0	13	0	0	0	3	0.5
Summer flounder	*Paralichthys dentatus*	89	3	46	3.4	46	8	5	0	20	0.5	10	1	0	4	0.2	1	6	1	0	2	0.3
Grubby	*Myoxecephalus aenaeus*	13	0	7	0.5	8	0	0	0	3	0.1	0	0	0	0	0.0	4	0	0	0	1	0.1
Red hake	*Urophycis chuss*	1	0	1	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Windowpane	*Scophthalmus aquosus*	13	1	7	0.5	4	0	0	0	1	0.0	2	0	0	1	0.0	19	0	2	0	5	0.7
Butterfish	*Peprillus tracanthus*	0	0	0	0.0	42	0	1	55	14	0.3	18	0	37	18	0.9	23	0	20	15	15	2.1
Bluefish	*Pomatomus saltatrix*	3	0	2	0.1	7	5	0	17	4	0.1	18	32	61	37	1.8	3	6	3	22	9	1.2
American shad	*Alosa sapidissima*	0	0	0	0.0	3	1	0	0	1	0.0	2	9	0	4	0.2	0	3	1	0	1	0.1
Striped searobin	*Prionotus evolans*	3	0	2	0.1	9	0	1	2	3	0.1	45	0	8	18	0.9	25	0	3	5	8	1.2
Atlantic croaker	*Micropogonia undulatus*	0	0	0	0.0	7	0	0	2	2	0.1	3	0	0	1	0.0	4	0	0	0	1	0.1
Smallmouth flounder	*Etropus microstomus*	0	0	0	0.0	0	0	0	1	0	0.0	2	0	0	1	0.0	0	0	0	0	0	0.0
Northern searobin	*Prionotus carollnus*	7	0	4	0.3	10	0	1	0	4	0.1	0	0	0	0	0.0	2	0	0	0	1	0.1
Silver perch	*Bairdiella chrysura*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	8	0	0	0	2	0.3
Northern pipefish	*Syngnathus fuscus*	4	6	5	0.4	1	0	0	1	0	0.0	2	0	2	1	0.1	0	0	0	0	0	0.0
Scup	*Stenotomus chrysops*	0	0	0	0.0	0	0	31	1	10	0.2	0	0	1	0	0.0	1	0	0	2	1	0.1
Silver hake	*Merluccius bilinearis*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Hogchoker	*Trinectes maculatus*	1	0	1	0.0	2	0	0	0	1	0.0	7	0	0	2	0.1	0	0	0	1	0	0.0
Silverside	Atherinidae (unidentified)	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Threespine stickleback	*Gasterosteus aculeatus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
American eel	*Anguilla rostrata*	0	0	0	0.0	1	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Cunner	*Tautogolabrus adspersus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Tautog	*Tautoga onitis*	0	0	0	0.0	1	0	0	0	0	0.0	0	0	0	0	0.0	0	0	1	0	0	0.0
Northern kingfish	*Menticirrhus saxatillis*	0	0	0	0.0	3	0	0	0	1	0.0	0	6	2	3	0.1	0	0	1	2	1	0.1
Spot	*Leiostomus santhurus*	0	0	0	0.0	3	0	0	0	1	0.0	2	0	1	1	0.0	1	0	0	0	0	0.0
Crevalle Jack	*Caranx hippos*	0	0	0	0.0	0	0	0	1	0	0.0	2	3	0	2	0.1	1	0	0	0	0	0.0
Black sea bass	*Centropristis striata*	0	0	0	0.0	0	0	0	8	0	0.0	0	0	0	0	0.0	0	0	0	4	1	0.1
Herring	Clupeidae (unidentified)	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Northern puffer	*Sphaeroldes maculatus*	0	0	0	0.0	1	1	0	0	1	0.0	1	0	0	0	0.0	0	0	0	0	0	0.0
Rock gunnel	*Pholis gunnellus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Striped killifish	*Fundulus majalis*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Little skate	*Raja erinacea*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Naked goby	*Gobiosoma bosc*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Fourspot flounder	*Paralichthys oblongus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Lookdown	*Selene vomer*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	1	0	0.0	0	0	2	0	1	0.1
Oyster toadfish	*Opsanus tau*	0	0	0	0.0	0	0	0	2	0	0.0	0	0	0	0	0.0	0	0	0	1	0	0.0
Seaboard Goby	*Gobiosoma ginsburgi*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Mummichog	*Fundulus heteroclitus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
American sandlance	*Ammodytes americanus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Atlantic sturgeon	*Acipenser oxyrhynchus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Chub mackerel	*Scomber japonicus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Clearnose skate	*Raja eglanteria*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Conger eel	*Conger oceanicus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Goby	*Gobiidee sp.*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Lined seahorse	*Hippocampus erectus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Northern stargazer	*Astroscopus guttatus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
Planehead filefish	*Monacanthus hispidus*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	1	0	0	0	0	0.0
Striped cuskeel	*Ophidion marginatum*	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	0	0.0
	TOTALS	**2497**	**216**			**2409**	**801**	**649**	**12812**			**2110**	**1844**	**2145**			**1246**	**83**	**310**	**1174**		
	Monthly Average		**1357**					**4168**					**2033**						**703**			

Notes:
Based on catch per unit effort (CPUE).

Acronyms and Abbreviations:
LMS = Lawler, Matusky and Skelly Engineers, Inc.
NOAA = National Oceanic and Atmospheric Administration
USACE = U.S. Army Corps of Engineers

Sources:

USACE. 2004, 2005, 2006, 2007, 2008, and 2009. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.

NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.

LMS. 1996. *Biological Survey of Newark Bay Shoal Areas and Adjacent Kill Van Kull and Arthur Kill Channels.* Lawler, Matusky and Skelly Engineers, Inc. Prepared for the Port Authority of New York and New Jersey.

Table 3-4
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2009)

		November					December								Overall	
Common Name	**Scientific Name**	**Nov-93**	**Nov-95**	**Nov-06**	**Average**	**Average % Comp**	**Dec-93**	**Dec-95**	**Dec-98**	**Dec-01**	**Dec-02**	**Dec-09**	**Average**	**Average % Comp**	**Species Avg**	**Avg Percent Comp (%)**
White perch	*Morone americana*	507	1	23	254	19.1	272	0	77	0	459	15	137	42.8	114.92	19.355
Striped bass	*Morone saxatillis*	1748	0	41	874	65.6	205	0	70	0	135	1	69	21.4	162.61	20.528
Bay anchovy	*Anchoa mitchilli*	5	0	195	3	0.2	9	0	7	0	1	71	15	4.6	242.70	16.924
Atlantic herring	*Clupea harengus*	17	0	0	9	0.6	0	0	0	0	0	0	0	0.0	44.11	5.242
Atlantic tomcod	*Microgadus tomcod*	277	0	0	139	10.4	110	0	0	0	0	0	18	5.7	100.08	8.208
Weakfish	*Cynoscion regalis*	104	0	12	52	3.9	4	1	9	0	0	0	2	0.7	96.31	5.793
Spotted hake	*Urophycis regla*	20	0	9	10	0.8	15	0	2	0	3	0	3	1.0	23.66	3.882
Winter flounder	*Pleuronectes americanus*	371	1	5	186	14.0	169	3	8	0	16	4	33	10.4	49.00	5.153
Alewife	*Alosa pseudoharengus*	161	0	18	81	6.0	4	0	15	0	42	4	11	3.4	13.65	1.813
Blueback herring	*Alosa aestivalls*	2	0	157	1	0.1	8	0	0	3	5	46	10	3.2	6.35	1.160
Atlantic menhaden	*Brevooria tyrannus*	4	0	6	2	0.2	0	0	0	0	7	0	1	0.4	22.87	2.838
Rainbow smelt	*Osmerus mordax*	0	0	0	0	0.0	5	0	0	0	0	0	1	0.3	3.40	0.555
Atlantic silverside	*Menidia menidia*	3	4	22	4	0.3	8	0	1	0	0	2	2	0.6	5.87	0.679
Gizzard shad	*Dorosoma cepedianum*	196	0	4	98	7.4	18	0	3	0	7	3	5	1.6	9.90	0.942
Summer flounder	*Paralichthys dentatus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	7.39	0.579
Grubby	*Myoxecephalus aenaeus*	6	0	0	3	0.2	23	0	0	0	0	0	4	1.2	3.54	0.538
Red hake	*Urophycis chuss*	0	0	0	0	0.0	13	0	0	0	0	0	2	0.7	1.59	0.273
Windowpane	*Scophthalmus aquosus*	19	0	0	10	0.7	5	0	1	0	0	1	1	0.4	2.85	0.347
Butterfish	*Peprillus tracanthus*	1	0	3	1	0.0	0	0	1	0	0	0	0	0.1	4.11	0.301
Bluefish	*Pomatomus saltatrix*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	4.57	0.318
American shad	*Alosa sapidissima*	5	0	7	3	0.2	2	0	10	0	0	0	2	0.6	1.48	0.207
Striped searobin	*Prionotus evolans*	7	0	1	4	0.3	0	0	1	0	0	0	0	0.1	2.99	0.232
Atlantic croaker	*Micropogonia undulatus*	5	0	1	3	0.2	3	0	0	0	0	0	1	0.2	1.05	0.120
Smallmouth flounder	*Etropus microstomus*	3	0	3	2	0.1	2	0	2	0	0	1	1	0.3	0.67	0.134
Northern searobin	*Prionotus carollnus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.92	0.076
Silver perch	*Bairdiella chrysura*	13	0	0	7	0.5	0	0	0	0	0	0	0	0.0	0.88	0.092
Northern pipefish	*Syngnathus fuscus*	0	0	0	0	0.0	0	0	0	0	0	1	0	0.1	0.80	0.085
Scup	*Stenotomus chrysops*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.98	0.035
Silver hake	*Merluccius bilinearis*	0	0	2	0	0.0	0	0	0	0	1	0	0	0.1	0.25	0.056
Hogchoker	*Trinectes maculatus*	0	0	0	0	0.0	2	0	0	0	0	0	0	0.1	0.45	0.044
Silverside	Atherinidae (unidentified)	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.22	0.035
Threespine stickleback	*Gasterosteus aculeatus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.18	0.030
American eel	*Anguilla rostrata*	2	0	1	1	0.1	1	0	0	0	0	0	0	0.1	0.27	0.034
Cunner	*Tautogolabrus adspersus*	0	0	0	0	0.0	0	0	0	0	0	1	0	0.1	0.13	0.027
Tautog	*Tautoga onitis*	3	0	0	2	0.1	1	0	0	0	0	0	0	0.1	0.24	0.026
Northern kingfish	*Menticirrhus saxatillis*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.37	0.022
Spot	*Leiostomus santhurus*	0	0	2	0	0.0	0	0	0	0	0	0	0	0.0	0.20	0.011
Crevalle Jack	*Caranx hippos*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.16	0.010
Black sea bass	*Centropristis striata*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.13	0.020
Herring	Clupeidae (unidentified)	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.03	0.007
Northern puffer	*Sphaeroldes maculatus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.09	0.005
Rock gunnel	*Pholis gunnellus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.03	0.008
Striped killifish	*Fundulus majalis*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.03	0.005
Little skate	*Raja erinacea*	1	0	1	1	0.0	0	0	0	0	0	0	0	0.0	0.06	0.007
Naked goby	*Gobiosoma bosc*	0	0	0	0	0.0	0	0	0	0	1	0	0	0.1	0.03	0.007
Fourspot flounder	*Paralichthys oblongus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.02	0.003
Lookdown	*Selene vomer*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.07	0.007
Oyster toadfish	*Opsanus tau*	0	0	1	0	0.0	0	0	0	0	0	0	0	0.0	0.04	0.005
Seaboard Goby	*Gobiosoma ginsburgi*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.02	0.003
Mummichog	*Fundulus heteroclitus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.002
American sandlance	*Ammodytes americanus*	0	0	0	0	0.0	0	0	0	0	1	0	0	0.1	0.01	0.004
Atlantic sturgeon	*Acipenser oxyrhynchus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.002
Chub mackerel	*Scomber japonicus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.002
Clearnose skate	*Raja eglanteria*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.001
Conger eel	*Conger oceanicus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.001
Goby	*Gobiidee sp.*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.002
Lined seahorse	*Hippocampus erectus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.002
Northern stargazer	*Astroscopus guttatus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.001
Planehead filefish	*Monacanthus hispidus*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.02	0.003
Striped cuskeel	*Ophidion marginatum*	0	0	0	0	0.0	0	0	0	0	0	0	0	0.0	0.01	0.001
	TOTALS	**3480**	**6**	**514**			**879**	**4**	**207**	**3**	**678**	**150**				
	Monthly Average		**1333**									**320**		**700**		

Notes:
Based on catch per unit effort (CPUE).

Acronyms and Abbreviations:
LMS = Lawler, Matusky and Skelly Engineers, Inc.
NOAA = National Oceanic and Atmospheric Administration
USACE = U.S. Army Corps of Engineers

Sources:
USACE. 2004, 2005, 2006, 2007, 2008, and 2009. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project.* U.S. Army Corps of Engineers, New York District, New York, New York.
NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994.* Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: http://sh.nefsc.noaa.gov.
LMS. 1996. *Biological Survey of Newark Bay Shoal Areas and Adjacent Kill Van Kull and Arthur Kill Channels.* Lawler, Matusky and Skelly Engineers, Inc. Prepared for the Port Authority of New York and New Jersey.

Table 3-5
Mammal and Reptile Species that could Possibly Use the NBSA

Common Name	Scientific Name	Season	Habitat
Mammals			
Eastern pipistrelle	*Pipistrellus subflavus*	Spring to fall	Aerial – over land and water
Big brown bat	*Eptesicus fuscus*	Spring to fall	Aerial – over land and water
Red bat	*Lasiurus borealis*	Spring to fall	Aerial – over land and water
Hoary bat	*Lasiurus cinereus*	Spring to fall	Aerial – over land and water
Evening bat	*Nycticeius humeralis*	Spring to fall	Aerial – over land and water
Silver-haired bat	*Lasionycteris noctivagans*	Spring to fall	Aerial – over land and water
Small-footed bat	*Myotis leibii*	Spring to fall	Aerial – over land and water
Little brown bat	*Myotis lucifugus*	Spring to fall	Aerial – over land and water
Northern long-eared bat	*Myotis septentrionalis*	Spring to fall	Aerial – over land and water
Muskrat	*Ondatra zibethica*	Spring to fall	Marsh – wetland, riverine, small bays, and creeks
River otter	*Lutra canadensis*	Spring to fall	Marsh – wetland, riverine, small bays, and creeks
Harbor seal	*Phoca vitulina*	All year	Marine bays, channels, and coastal waters
Reptiles			
Loggerhead	*Caretta caretta*	Summer	Coastal waters
Kemp’s ridley	*Lepidochelys kempii*	Summer	Coastal waters
Green sea turtle	*Chelonias mydas*	Summer	Coastal waters
Diamondback terrapin	*Malaclemys terrapin*	Spring to summer	Marsh – wetland, riverine, small bays, and creeks

Acronyms and Abbreviations:
NBSA = Newark Bay Study Area
USACE = U.S. Army Corps of Engineers

Source:
Adapted from USACE. 1997. *Final Environmental Impact Statement on the Newark Bay Confined Disposal Facility.* U.S. Army Corps of Engineers, New York District, New York, New York. April.

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Loons					
Loon, common	–	✓	✓	✓	–
Loon, red-throated	–	✓	–	✓	–
Grebes					
Grebe, eared	–	–	–	✓	–
Grebe, horned	–	✓	–	✓	–
Grebe, pied-billed	–	✓	–	✓	–
Pelicaniformes					
Cormorant, double-crested	✓	✓	✓	✓	✓
Cormorant, great	–	–	–	✓	–
Pelican, brown	–	–	–	✓	–
Wading Birds					
Bittern, American	–	✓	–	✓	–
Bittern, least	–	✓	–	✓	–
Egret, cattle	–	✓	✓	✓	✓
Egret, great	✓	✓	✓	✓	✓
Egret, snowy	✓	✓	✓	✓	✓
Heron, black-crowned night	✓	✓	✓		✓
Heron, great blue	✓	✓	–	✓	–
Heron, green	✓	✓	✓	✓	✓
Heron, little blue	✓	✓	✓	✓	✓
Heron, tricolored	–	✓	✓	✓	✓
Heron, yellow-crowned night	–	✓	✓	✓	
Ibis, glossy	–	✓	✓	✓	✓
Swans, Geese and Ducks					
Brant	–	✓	✓	✓	–
Bufflehead	–	✓	–	✓	–
Canvasback		✓	✓	✓	–
Duck, American black	✓	✓		✓	✓
Duck, fulvous whistling	–	✓	–	–	–
Duck, long-tailed	–	✓	–	✓	–
Duck, ring-necked	–	✓	–	–	–
Duck, ruddy	–	✓	–	✓	–
Duck, wood	✓	✓	–	✓	–
Gadwall	–	✓	✓	✓	✓
Goldeneye, common	–	✓	–	✓	–
Goose, Canada	✓	✓	✓	✓	✓
Goose, snow	–	✓	–	–	–
Mallard	✓	✓	✓	✓	✓
Merganser, common	✓	–	–	✓	–
Merganser, hooded	–	✓	–	✓	–
Merganser, red-breasted	–	✓	–	✓	–
Northern pintail	–	✓	–	✓	–
Northern shoveler	–	✓	–	✓	–
Redhead	–	✓	–	–	–
Scaup, greater	–	✓	✓	✓	–
Scaup, lesser	–	✓	–	✓	–
Scoter, black	✓	–	–	✓	–
Scoter, surf	–	✓	–	✓	–
Scoter, white-winged	✓	✓	–	✓	–
Swan, mute	–	✓	–	✓	–

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Swan, tundra	–	✓	–	–	–
Teal, blue-winged	–	✓	–	✓	–
Teal, green-winged	–	✓	–	✓	–
Wigeon, American	–	–	–	✓	–
Diurnal Raptors					
American kestrel	✓	✓	✓	✓	–
Bald eagle	–	✓	✓	–	–
Falcon, peregrine	✓	✓	✓	✓	–
Hawk, broad-winged	–	✓	✓	✓	–
Hawk, Cooper's	–	✓	✓	✓	–
Hawk, red-shouldered	–	✓	✓	✓	–
Hawk, red-tailed	✓	✓	✓	✓	–
Hawk, rough-legged	–	✓	–	✓	–
Hawk, sharp-shinned	–	✓	✓	✓	–
Merlin	–	✓	✓	✓	–
Northern goshawk	–	✓	–	–	–
Northern harrier	–	✓	✓	✓	✓
Osprey	✓	✓	✓	✓	–
Vulture, turkey	–	✓	✓	✓	–
Upland Game Birds					
Pheasant, ring-necked	–	✓	–	✓	✓
Gruiformes					
American coot	–	✓	–	✓	–
Common moorhen	–	✓	–	✓	✓
Rail, clapper	–	✓	–	✓	–
Rail, king	–	✓	–	–	–
Rail, Virginia	–	✓	–	✓	✓
Rail, yellow	–	✓	–	–	–
Sora	–	✓	–	✓	–
Shorebirds					
American avocet	–	✓	–	–	–
American oystercatcher	–	–	✓	–	–
American woodcock	–	✓	✓	✓	–
Common snipe	–	✓	–	✓	–
Dunlin	–	✓	–	✓	–
Dowitcher, long-billed	–	✓	–	✓	–
Dowitcher, short-billed	–	✓	–	–	–
Godwit, Hudsonian	–	✓	–	–	–
Godwit, marbled	–	✓	–	–	–
Killdeer	✓	✓	–	✓	–
Phalarope, red	–	✓	–	–	–
Phalarope, Wilson's	–	✓	–	–	–
Plover, American golden	–	✓	✓	–	–
Plover, black-bellied	–	✓	–	✓	–
Plover, semipalmated	–	✓	–	✓	–
Red knot	–	✓	–	✓	–
Ruff	–	✓	–	–	–
Sanderling	–	✓	–	✓	–
Sandpiper, Baird's	–	✓	–	–	–
Sandpiper, buff-breasted	–	✓	–	–	–
Sandpiper, curlew	–	✓	–	–	–

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Sandpiper, least	✓	✓	–	✓	–
Sandpiper, pectoral	–	✓	–	✓	–
Sandpiper, purple	–	–	–	✓	–
Sandpiper, semipalmated	–	✓	–	✓	–
Sandpiper, solitary	–	✓	–	✓	–
Sandpiper, spotted	✓	✓	✓	✓	✓
Sandpiper, stilt	–	✓	–	–	–
Sandpiper, upland	–	✓	✓	–	–
Sandpiper, western	–	✓	–	–	–
Sandpiper, white-rumped	–	✓	–	–	–
Stilt, black-necked	–	✓	–	–	–
Turnstone, ruddy	–	✓	–	✓	–
Whimbrel	–	✓	–	✓	–
Willet	–	✓	–	✓	–
Yellowlegs, greater	✓	✓	–	✓	–
Yellowlegs, lesser	✓	✓	–	–	–
Gulls, Terns and Skimmers					
Gull, great black-backed	✓	✓	✓	✓	✓
Gull, Bonaparte's	–	✓	–	✓	–
Gull, common black-headed	✓	✓	–	✓	–
Gull, glaucus	–	✓	–	✓	–
Gull, herring	✓	✓	✓	✓	✓
Gull, Iceland	–	✓	–	–	–
Gull, laughing	✓	✓	✓	✓	–
Gull, little	–	–	–	✓	–
Gull, ring-billed	✓	✓	✓	✓	–
Skimmer, black	–	✓	–	–	–
Tern, black	–	✓	–	✓	–
Tern, Caspian	–	✓	–	✓	–
Tern, common	–	✓	✓	✓	–
Tern, Forster's	–	✓	–	✓	–
Tern, gull-billed	–	✓	–	✓	–
Tern, least	–	✓	✓	✓	–
Tern, roseate	–	✓	–	✓	–
Tern, royal	–	✓	–	–	–
Pigeons and Doves					
Dove, mourning	✓	✓	✓	✓	–
Dove, rock	✓	✓	✓	✓	✓
Cuckoos and their Allies					
Cuckoo, black-billed	–	✓	–	✓	–
Cuckoo, yellow-billed	–	✓	✓	✓	–

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Owls					
Owl, barn	–	✓	–	✓	–
Owl, barred	–	–	–	✓	–
Owl, eastern-screech	–	✓	–	–	–
Owl, great horned	–	✓	–	✓	–
Owl, long-eared	–	✓	–	–	–
Owl, short-eared	–	✓	–	✓	–
Owl, snowy	–	✓	–	–	–
Goatsuckers and Swifts					
Chimney swift	–	✓	–	✓	–
Nighthawk, common	–	✓	–	✓	–
Hummingbirds					
Hummingbird, ruby-throated	–	✓	–	✓	–
Kingfishers					
Kingfisher, belted	✓	✓	✓	✓	✓
Woodpeckers					
Flicker, northern	–	✓	–	✓	✓
Sapsucker, yellow-bellied	–	✓	–	✓	✓
Woodpecker, hairy	–	✓	–	–	–
Woodpecker, red-bellied	–	–	–	✓	–
Woodpecker, downy	–	✓	✓	✓	✓
Woodpecker, red-headed	–	✓	–	–	–
Tyrant Flycatchers					
Eastern wood-pewee	–	✓	–	✓	–
Flycatcher, great-crested	–	✓	–	✓	–
Flycatcher, least	–	✓	–	✓	–
Flycatcher, olive-sided	–	–	–	✓	–
Flycatcher, willow	–	–	–	✓	–
Flycatcher, yellow-bellied	–	✓	–	✓	–
Kingbird, eastern	✓	✓	–	✓	–
Kingbird, western	–	✓	✓	–	–
Phoebe, eastern	–	✓	–	✓	✓
Wood-pewee, eastern	–	–	–	✓	–
Shrikes and Vireos					
Shrike, northern	–	✓	–	–	–
Vireo, red-eyed	–	✓	–	✓	✓
Vireo, solitary	–	✓	–	✓	–
Vireo, warbling	–	✓	✓	✓	–
Vireo, white-eyed	–	✓	–	–	–
Vireo, yellow-throated	–	✓	–	–	–
Jays, Crows and their Allies					
Crow, American	✓	✓	✓	✓	–
Crow, fish	✓	✓	✓	✓	–
Jay, blue	✓	✓	–	✓	–
Larks					
Lark, horned	–	✓	–	–	–

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Swallows					
Purple martin	–	✓	✓	–	–
Swallow, bank	–	✓	–	✓	–
Swallow, barn	✓	✓	✓	✓	–
Swallow, cliff	–	✓	–	–	–
Swallow, northern rough-winged	✓	✓	–	✓	–
Swallow, tree	–	✓	✓	✓	–
Chickadees and their Allies					
Chickadee, black-capped	–	✓	–	✓	–
Titmouse, tufted	–	✓	–	✓	–
Nuthatches and Creepers					
Brown creeper	–	✓	–	✓	–
Nuthatch, red-breasted	–	✓	–	✓	–
Nuthatch, white-breasted	–	✓	–	✓	–
Wrens					
Wren, Carolina	–	✓	✓	✓	–
Wren, house	–	✓	✓	✓	✓
Wren, marsh	–	✓	–	✓	–
Wren, sedge	–	✓	–	–	–
Wren, winter	–	✓	–	✓	–
Old World Warblers, Thrushes and their Allies					
Robin, American	–	✓	–	✓	✓
Gnatcatcher, blue-gray	–	✓	–	✓	–
Kinglet, golden-crowned	–	✓	–	✓	✓
Kinglet, ruby-crowned	–	✓	–	✓	✓
Thrush, gray-cheeked	–	✓	✓	✓	–
Thrush, hermit	–	✓	–	✓	✓
Thrush, Swainson's	–	✓	✓	✓	✓
Thrush, wood	–	✓	–	✓	–
Veery	–	✓	–	✓	–
Mimids					
Brown thrasher	–	✓	–	✓	✓
Catbird, gray	✓	✓	✓	✓	✓
Mockingbird, northern	✓	✓	–	✓	–
Starlings and Minas					
Starling, European	✓	✓	✓	✓	–
Wagtails and Pipits					
American pipit	–	✓	–	–	–
Waxwings					
Waxwing, cedar	–	✓	–	✓	✓
Wood-Warblers					
American redstart	–	✓	✓	✓	✓
Chat, yellow-breasted	–	–	✓	–	–
Northern parula	–	✓	–	✓	–
Ovenbird	–	✓	–	✓	✓
Warbler, bay-breasted	–	✓	–	✓	–
Warbler, black-and-white	–	✓	✓	✓	✓
Warbler, blackburnian	–	✓	–	✓	–
Warbler, blackpoll	–	✓	–	✓	✓
Warbler, black-throated blue	–	✓	✓	✓	✓
Warbler, black-throated green	–	✓	–	✓	–

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Warbler, blue-winged	–	✓	–	✓	✓
Warbler, Canada	–	✓	–	✓	–
Warbler, Cape May	–	✓	–	✓	–
Warbler, cerulean	–	–	✓	✓	–
Warbler, chestnut-sided	–	✓	–	✓	✓
Warbler, Connecticut	–	✓	✓	✓	✓
Warbler, golden-winged	–	–	✓	–	–
Warbler, hooded	–	–	✓	✓	–
Warbler, Kentucky	–	–	–	✓	–
Warbler, magnolia	–	✓	✓	✓	✓
Warbler, mourning	–	–	✓	✓	–
Warbler, Nashville	–	✓	–	✓	✓
Warbler, orange-crowned	–	✓	–	–	–
Warbler, palm	–	✓	–	✓	✓
Warbler, pine	–	–	✓	–	–
Warbler, prairie	–	✓	–	✓	–
Warbler, prothonotary	–	–	–	✓	–
Warbler, Tennessee	–	✓	–	✓	–
Warbler, Wilson's	–	✓	–	–	✓
Warbler, worm-eating	–	–	✓	✓	–
Warbler, yellow	–	✓	✓	✓	–
Warbler, yellow-rumped	–	✓	–	✓	✓
Warbler, yellow-throated	–	–	✓	✓	–
Waterthrush, Louisiana	–	✓	–	✓	–
Waterthrush, northern	–	✓	✓	✓	✓
Yellowthroat, common	–	✓	–	✓	✓
Tanagers, Cardinals and their Allies					
Bunting, indigo	–	✓	–	✓	–
Dickcissel	–	✓	–	–	–
Grosbeak, blue	–	✓	–	–	–
Grosbeak, rose-breasted	–	✓	–	✓	–
Northern cardinal	✓	✓	–	✓	–
Tanager, scarlet	–	✓	–	✓	–
Emberizine Sparrows and their Allies					
Bunting, snow	–	✓	–	–	–
Junco, dark-eyed	–	✓	–	✓	✓
Longspur, lapland	–	✓	–	–	–
Sparrow, American tree	✓	✓	–	✓	–
Sparrow, chipping	–	✓	–	✓	–
Sparrow, field	–	✓	–	✓	✓
Sparrow, fox	–	✓	✓	–	–
Sparrow, Lincoln's	–	✓	✓	–	–
Sparrow, Savannah	–	✓	–	✓	–
Sparrow, seaside	–	✓	–	✓	–
Sparrow, sharp-tailed	–	✓	–	✓	–
Sparrow, song	✓	✓	✓	✓	✓
Sparrow, swamp	–	✓	–	✓	✓
Sparrow, vesper	–	✓	–	–	–
Sparrow, white-crowned	–	✓	–	✓	–
Sparrow, white-throated	✓	✓	–	✓	✓
Towhee, eastern	–	✓	–	✓	✓

Table 3-6
Inventory of Bird Observations in the Newark Bay Study Area

Species	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull
Icterids					
Blackbird, red-winged	✓	✓	–	✓	–
Blackbird, rusty	–	✓	–	–	–
Blackbird, yellow-headed	–	✓	–	–	–
Bobolink	–	✓	–	–	–
Cowbird, brown-headed	–	✓	–	✓	–
Eastern meadowlark	–	✓	–	✓	–
Grackle, common	✓	✓	✓	✓	–
Grackle, boat-tailed	–	–	–	✓	–
Oriole, Baltimore	–	✓	✓	✓	–
Oriole, orchard	–	–	✓	–	–
Finches and Old World Sparrows					
Common redpoll	–	✓	–	–	–
Finch, house	✓	✓	–	✓	–
Finch, purple	–	✓	–	✓	–
Goldfinch, American	✓	✓	✓	✓	✓
Siskin, pine	–	✓	–	✓	–
Sparrow, house	✓	✓	–	✓	–
Total Number of Species	**49**	**248**	**81**	**213**	**59**

Notes:

1. ✓ indicates species was observed during any of the following surveys: Tierra (2004), Ludwig et al. (2010), Kerlinger (2004), Bernick (2007), Bernick and Craig (2008), Mizrahi et al. (2006).
2. The Passaic River Bird Survey was conducted on the lower six miles of the river.

Sources:

Bernick, A.J. 2007. *NYC Audubon's Harbor Herons Project: 2007 Nesting Survey.* NYC Audubon, New York. 48 pp.

Bernick, A.J. and E. Craig. 2008. *NYC Audubon's Harbor Herons Project: 2008 Interim Nesting Survey.* NYC Audubon, New York. 42 pp.

Kerlinger, P. 2004. *NYC Audubon's Harbor Herons Project: 2004 Nesting Survey.* NYC Audubon, New York. 30 pp.

Ludwig, D.F., J. Iannuzzi, T.J. Iannuzzi, and J.K. Shisler. 2010. Spatial and temporal habitat use patterns by water birds in an urban estuarine ecosystem: Implications for ecosystem management and restoration. *Human Ecol Risk Assess* 16(1):163-184.

Mizrahi, D.S., N. Tsipoura, and K. Witkowski. 2007. *Avian Abundance and Distribution in the New Jersey Meadowlands District: The Importance of Habitat, Landscape, and Disturbance.* New Jersey Audubon Society. A Final Report Submitted to New Jersey Meadowlands Commission. November 28.

Tierra. 2004. *Newark Bay Study Area RIWP. Sediment Sampling and Source Identification Program. Volume 1 of 3. Inventory Report.* Revision 0. Tierra Solutions, Inc., East Brunswick, New Jersey. June.

Table 3-7
Sediment and Tissue Datasets for Use in Risk Assessments

Date	Author	Title	Media
1980	Ellis et al.	A Comprehensive Monitoring and Assessment Program for Selected Heavy Metals in New Jersey Aquatic Fauna	Tissue
1982	NJDEP	PCBs in Fish: 1975-1980. A Comprehensive Survey	Tissue
1983	NJDEP	PCBs in Selected Finfish Caught Within New Jersey Waters 1981-1982 (With Limited Chlordane Data)	Tissue
1985	NJDEP	A Study of Dioxin (2,3,7,8-Tetrachlorodibenzo-p-Dioxin) Contamination in Select Finfish, Crustaceans and Sediments of New Jersey Waterways	Tissue
1991	Rappe et al.	Levels and Patterns of PCDD and PCDF Contamination in Fish, Crabs, and Lobsters from Newark Bay and the Newark Bight	Tissue
1991	Woodhead, P.M.J.	Module 5.3 Inventory and Characterization of Habitat and Fish Resources and Assessment of Information on Toxic Effects of the New York-New Jersey Harbor Estuary	Tissue
1994	Brown et al.	Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Mya arenaria in the Newark/Raritan Bay Estuary	Tissue
1997	NOAA	Fish, Megainvertebrates, and Associated Hydrographic Observations Collected in Newark Bay, New Jersey, during May 1993 – April 1994	Tissue
1999	USACE	New York and New Jersey Harbor Navigation Study. Biological Monitoring Program 1998-1999, Volume I of II	Tissue
2000	Gale et al.	Evaluation of Planar Halogenated and Polycyclic Aromatic Hydrocarbons in Estuarine Sediments using Ethoxyresorufin-O-Deethylase Induction of H4IIE Cells	Tissue
2000	USFWS	Impacts of Dioxins, Furans, and Polychlorinated Biphenyls on Anadromous Fish and Piscivorous Birds in Newark Bay. Pre Assessment Study for the Diamond Alkali Superfund Site, Newark, Essex County, New Jersey	Tissue
2001	Yuan et al.	Is Hepatic Cytochrome P4501A1 Expression Predictive of Hepatic Burdens of Dioxins, Furans, and PCBs in Atlantic Tomcod from the Hudson River Estuary?	Tissue
2002	Horwitz et al.	Environmental Assessment and Risk Analysis Element Research Project Summary: Assessment of Total Mercury Concentrations in Fish from Rivers, Lakes and Reservoirs in New Jersey	Tissue
2003	NYSDEC	Contaminant Assessment and Reduction Project: NY/NJ Harbor Sediment Report, 1998-2001	Sediment
2003	USACE	New York and New Jersey Harbor Navigation Project. Aquatic Biological Sampling Program Survey Report, 2001-2002.	Tissue
2003	USACE	New York/ New Jersey Harbor Navigation Project. Aquatic Biological Survey Report, 2002-2003	Tissue
2003	Wintermyer, M.L. and K.R. Cooper	Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg Fertilization and Development	Tissue
2004	Fernandez et al.	Spatial Variation in Hepatic Levels and Patterns of PCBs and PCDD/Fs among Young-of-the-Year and Adult Atlantic Tomcod (*Microgadus tomcod*) in the NY/NJ Harbor Estuary	Tissue
2004	NYSDEC	Polychlorinated Biphenyls (PCBs) in Five Fish Species from the New York-New Jersey Harbor Estuary	Tissue
2004	NYSDEC	Dioxins and Furans in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary	Tissue
2004	NYSDEC	Mercury, Methyl Mercury, Cadmium and Lead in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary	Tissue
2004	USACE	New York/New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2004	Tissue
2005	NOAA	Benthic Macrofauna and Associated Hydrographic Observations Collected in Newark Bay, New Jersey, between June 1993 and March 1994	Tissue
2005	NYSDEC	Organochlorine Pesticides in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary.	Tissue
2005	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2005	Tissue
2006	Academy of Natural Sciences	Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey. Second Year of Routine Monitoring Program. Final Report. Report No. 06-04F	Tissue
2006	NYSDEC	Polynuclear Aromatic Hydrocarbons (PAHs) in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary	Tissue
2007	Cooper, K.R. and G.A. Buchanan	Integrated Biomarkers for Assessing the Exposure and Effects of Endocrine Disruptors and Other Contaminants on Marine/Estuarine Fish	Tissue
2007	USACE	New York/New Jersey Harbor Deepening Project. Migratory Finfish Report, 2006	Tissue
2007	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2007	Tissue
2008	Bernick, A.J. and E. Craig.	NYC Audubon's Harbor Herons Project: 2008 Interim Nesting Survey	Tissue
2008	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2008	Tissue
2008	USACE	Dredging Operations Environmental Research Program. Dredged Material Analysis Tools. Performance of Acute and Chronic Sediment Toxicity Methods	Tissue
2009	Bugel, S.M.	An Integrated Biomarker Approach for Assessing Exposure and Effects of Endocrine Disruptors and other Contaminants in Killifish (Fundulus heteroclitus) from the New York-New Jersey Harbor Estuary	Tissue
2009	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2009	Tissue
2010	USACE	Dredging Operations and Environmental Research Program. Determining Steady-state Tissue Residues for Invertebrates in Contaminated Sediment.	Tissue

Table 3-7
Sediment and Tissue Datasets for Use in Risk Assessments

Date	Author	Title	Media
2010	USACE	Stratified Sampling Project Summary Report and Evaluation of Data. New York District. New York, NY	Sediment
2010	Tierra	Phase I and Phase II Data Evaluation and Analysis Report. Newark Bay Study Area Remedial Investigation. Revision 0. Tierra Solutions, Inc., East Brunswick, NJ. April.	Sediment
2011	Bugel, S.M.	Decreased Vitellogenin Inducibility and 17β-estradioal Levels Correlated with Reduced Egg Production in Killifish (Fundulus heteroclitus) from Newark Bay, NJ.	Tissue
2011	Pflugh et al.	Consumption Patterns and Risk Assessment of Crab Consumers from the Newark Bay Complex, New Jersey, USA	Tissue
1999-2006	Honeywell	Offshore Investigation Results Summary Report	Sediment

Notes:
Datasets are preliminarily deemed Level 2 or 3 from the ongoing secondary data evaluation.

Table 3-8
Summary of Amphipod Survival Studies in Newark Bay

Reference	Data Collection Date(s)	Data Collection Season(s)	Average or Range of Survival as % of Control
Battelle (1992)	1992	Not provided	37
Battelle (1997a)	1995	Summer	19 - 62
Battelle (1997b)	1995	Summer	67
NOAA (1995)	1991, 1993	Not provided	0 - 87
Rice et al. (1995)	1991	Spring	NA
Tierra (2004)	2000	Summer	35
USACE (1997)	1996	Spring	81 - 97
USEPA (1990)	not provided	Not provided	0 - 89
USEPA (1998)	1990 - 1994	Summer	8 - 94
USEPA (2003)	1998	Summer	0 - 99

Notes:
NA = not available

Sources:

Battelle. 1992. *Sediment Toxicity and Concentrations of Trace Metals in Sediment and Porewater in New York/New Jersey Harbor.* Ocean Sciences, Duxbury, MA. Submitted to New York City Department of Environmental Protection.

Battelle. 1997a. *Evaluation of Dredged Material Proposed for Ocean Disposal from Arthur Kill Project Area, New York.* Battelle, Sequim, WA.

Battelle. 1997b. *Evaluation of Dredged Material Proposed for Ocean Disposal from Hackensack River Project Area, New York.* Battelle, Sequim, WA.

NOAA. 1995. *Magnitude and Extent of Sediment Toxicity in the Hudson Raritan Estuary.* NOAA Technical Memorandum NOS ORCA 88. National Oceanic and Atmospheric Administration Silver Spring, MD.

Rice, C.A., P.D. Plesha, E. Casillas, D.A. Misitano, and J.P. Meador. 1995. Growth and survival of three marine invertebrate species in sediments from the Hudson-Raritan Estuary, New York. *Environ. Toxicol. Chem.* 14(11): 1931-1940.

Tierra. 2004. *Newark Bay Study Area RIWP. Sediment Sampling and Source Identification Program.* Volume 1 of 3. Inventory Report. Revision 0. Tierra Solutions, Inc., East Brunswick, New Jersey. June.

USACE. 1997. *Final Environmental Impact Statement on the Newark Bay Confined Disposal Facility.* U.S. Army Corps of Engineers, New York District, New York, New York. April.

USEPA. 1990.The Application of the Amphipod 10-Day Sediment Toxicity Test for Dredged Material Evaluation. Prepared by U.S. Environmental Protection Agency, Environmental Research Laboratory Narragansett, Rhode Island. Prepared for U.S. Environmental Protection Agency, Region II, New York, New York.

USEPA. 1998. *Sediment Quality of the NY/NJ Harbor System.* EPA/902/R-98/001. U.S. Environmental Protection Agency, Regional Environmental Monitoring and Assessment Program (REMAP), Edison, NJ.

USEPA. 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures.* EPA-600-R-02-013. Office of Research and Development. November.

Table 4-1
Summary of COPECs from the SLERA

Chemical	Sediment	Benthic Invertebrates	Fish	Mollusk	Crab	Avian Embryo
Metals						
Antimony	✓					
Arsenic	✓	✓		✓		
Cadmium	✓	✓		✓		✓
Chromium	✓	✓		✓		
Copper	✓	✓		✓		
Iron	✓					
Lead	✓	✓	✓	✓		
Manganese	✓					
Mercury	✓					
Mercury (Elemental)		✓	✓	✓	✓	✓
Mercury (Total)			✓	✓	✓	✓
Methyl mercury			✓		✓	✓
Nickel	✓	✓		✓		
Selenium	✓					
Silver	✓	✓		✓		
Zinc	✓	✓		✓		
VOCs						
Ethylbenzene	✓					
SVOCs (Non-PAHs)						
1,2,4-Trichlorobenzene	✓					
1,3-Dichlorobenzene	✓					
1,4-Dichlorobenzene	✓					
Bis(2-ethylhexyl)phthalate	✓					
SVOCs (PAHs)						
1-Methylnaphthalene						✓
1-Methylphenanthrene						✓
2,3,5-Trimethylnaphthalene						✓
2,6-Dimethylnaphthalene						✓
2-Methylnaphthalene	✓					✓
Acenaphthene	✓					✓
Acenaphthylene	✓					✓
Anthracene	✓					✓
Benzo(a)anthracene	✓	✓	✓	✓	✓	✓
Benzo(a)pyrene	✓	✓		✓		✓
Benzo(b)fluoranthene	✓	✓		✓	✓	
Benzo(g,h,i)perylene	✓					✓
Benzo(k)fluoranthene	✓	✓		✓	✓	
Benzo[e]pyrene						✓
Benzofluoranthenes (total)	✓					
Biphenyl						✓
Chrysene	✓	✓	✓	✓	✓	✓
Dibenzo(a,h)anthracene	✓	✓	✓	✓		✓
Fluoranthene	✓					✓
Fluorene	✓					✓
Indeno[1,2,3-cd]-pyrene	✓	✓	✓	✓	✓	✓
Naphthalene	✓					✓
Perylene						✓
Phenanthrene	✓					✓
Pyrene	✓					✓
Total PAHs	✓	✓	✓	✓	✓	✓
HMW PAHs	✓	✓	✓	✓	✓	✓
LMW PAHs	✓	✓	✓	✓	✓	✓
PCBs						
Aroclor 1016			✓			

Table 4-1
Summary of COPECs from the SLERA

Chemical	Sediment	Benthic Invertebrates	Fish	Mollusk	Crab	Avian Embryo
Metals						
Antimony	✓					
Aroclor 1242	✓		✓			✓
Aroclor 1248	✓		✓			✓
Aroclor 1254	✓		✓	✓	✓	✓
Aroclor 1260	✓					✓
PCB 18CONGX2	✓					✓
Total Aroclor	✓		✓	✓	✓	✓
Total PCBs	✓	✓	✓	✓	✓	✓
Pesticides/Herbicides						
2,4'-DDD	✓	✓				✓
2,4'-DDE	✓			✓		✓
2,4'-DDT	✓					✓
4,4'-DDD	✓	✓	✓	✓		✓
4,4'-DDE	✓	✓	✓	✓		✓
4,4'-DDT	✓	✓				✓
Total DDx	✓	✓	✓	✓	✓	✓
Aldrin	✓	✓		✓		✓
alpha-BHC	✓					✓
beta-BHC	✓					✓
delta-BHC	✓					✓
gamma-BHC (Lindane)	✓					✓
Total BHC	✓					✓
Chlordane	✓					✓
Chlordane alpha (cis)	✓					✓
Chlordane gamma (trans)	✓					✓
Chlordane oxy	✓					✓
Total chlordane	✓	✓	✓	✓	✓	✓
Dieldrin	✓	✓	✓	✓		✓
Endrin	✓					✓
Endrin aldehyde						✓
Endrin ketone						✓
Total endrin	✓		✓			✓
Endosulfan sulfate						✓
Endosulfan alpha						✓
Endosulfan beta						✓
Total endosulfan	✓	✓		✓		✓
Heptachlor	✓					✓
Heptachlor epoxide	✓					✓
Total heptachlor	✓					✓
Hexachlorobenzene	✓					✓
Methoxychlor	✓					✓
Mirex						✓
Nonachlor cis-						✓
Nonachlor trans-						✓
Total Nonachlor			✓			✓

Table 4-1
Summary of COPECs from the SLERA

Chemical	Sediment	Benthic Invertebrates	Fish	Mollusk	Crab	Avian Embryo
Metals						
Antimony	✓					
Dioxins/Furans						
2,3,7,8-TCDD	✓					✓
DIOX_TEQ_BIRD		✓	✓		✓	✓
DIOX_TEQ_FISH			✓	✓	✓	✓
DIOX_TEQ_MAMMAL		✓	✓		✓	✓
PCB_TEQ_BIRD			✓	✓	✓	✓
PCB_TEQ_FISH			✓	✓	✓	✓
PCB_TEQ_MAMMAL			✓	✓	✓	✓
TOTAL_TEQ_BIRD		✓	✓	✓	✓	✓
TOTAL_TEQ_FISH			✓	✓	✓	✓
TOTAL_TEQ_MAMMAL	✓	✓	✓	✓	✓	✓

Acronyms and Abbreviations:
BHC = benzene hexachloride
COPEC = constituent of potential ecological concern
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
HMW = high molecular weight
LMW = low molecular weight
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyls
SLERA = screening level ecological risk assessment
SVOC = semi-volatile organic compound
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxic equivalent
VOC = volatile organic compound
DIOX_TEQ = dioxin TEQ
PCB_TEQ = dioxin-like PCBs TEQ
Total_TEQ = sum of dioxin and dioxin-like PCB TEQ

Source:
USEPA. 2008. *Screening-Level Ecological Risk Assessment for Newark Bay Study Area.* Submitted to USEPA Region 2 and USACE Kansas City District. Prepared by Battelle under contract to Malcolm Pirnie, Inc. December 15.

Table 4-2
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?
Dioxins/Furans (μg/kg)												
35822-46-9	1,2,3,4,6,7,8-HpCDD		NA	168/169	99%	0.267	0.00254	2.26	0.288	0.155	0.216	
67562-39-4	1,2,3,4,6,7,8-HpCDF		NA	169/169	100%	0.458	0.012941	7.82	0.882	0.218	0.242	
55673-89-7	1,2,3,4,7,8,9-HpCDF		NA	157/169	93%	0.0153	0.000452	0.165	0.0202	0.00866	0.0102	
39227-28-6	1,2,3,4,7,8-HxCDD		NA	142/169	84%	0.00379	0.0001	0.0231	0.00343	0.00264	0.00319	
70648-26-9	1,2,3,4,7,8-HxCDF		NA	167/169	99%	0.114	0.00273	2.21	0.247	0.0519	0.058752	
57653-85-7	1,2,3,6,7,8-HxCDD		NA	156/169	92%	0.0156	0.000544	0.0983	0.0156	0.00968	0.012991	
57117-44-9	1,2,3,6,7,8-HxCDF		NA	163/169	96%	0.0312	0.00075	0.401	0.0456	0.0159	0.0173	
19408-74-3	1,2,3,7,8,9-HxCDD		NA	151/169	89%	0.00875	0.000419	0.0505	0.00759	0.00596	0.00783	
72918-21-9	1,2,3,7,8,9-HxCDF		NA	116/169	69%	0.00409	0.000213	0.0502	0.00572	0.00226	0.00236	
40321-76-4	1,2,3,7,8-PeCDD		NA	144/169	85%	0.00378	0.000116	0.0471	0.00465	0.00249	0.00298	
57117-41-6	1,2,3,7,8-PeCDF		NA	161/169	95%	0.0127	0.000443	0.152	0.0181	0.0077	0.00909	
60851-34-5	2,3,4,6,7,8-HxCDF		NA	160/169	95%	0.0128	0.000498	0.135	0.0161	0.00775	0.0095	
57117-31-4	2,3,4,7,8-PeCDF		NA	161/169	95%	0.0216	0.000827	0.243	0.0285	0.0129	0.016	
1746-01-6	2,3,7,8-TCDD	0.0025	Recommended by Partner Agencies	167/169	99%	**0.0752**	0.00091	**1.35**	0.132	0.0371	0.0486	Yes
51207-31-9	2,3,7,8-TCDF		NA	160/169	95%	0.017	0.000738	0.16	0.0174	0.0111	0.0141	
3268-87-9	OCDD		NA	169/169	100%	2.65	0.079604	28.1	3.01	1.64	2.02	
39001-02-0	OCDF		NA	169/169	100%	0.744	0.01765	13.1	1.38	0.362	0.402	
37871-00-4	Total HpCDD		NA	168/169	99%	0.66	0.00665	5.31	0.707	0.397	0.509	
38998-75-3	Total HpCDF		NA	169/169	100%	0.615	0.01758	9.06	1.04	0.316	0.399	
34465-46-8	Total HxCDD		NA	168/169	99%	0.17	0.002405	1.1	0.166	0.106	0.142	
55684-94-1	Total HxCDF		NA	169/169	100%	0.424	0.00496	8.78	0.826	0.211	0.246	
36088-22-9	Total PeCDD		NA	158/169	93%	0.0509	0.000631	0.886	0.0769	0.0292	0.0401	
30402-15-4	Total PeCDF		NA	169/169	100%	0.408	0.00246	9.18	0.82	0.204	0.259	
41903-57-5	Total TCDD		NA	169/169	100%	0.142	0.00247	1.52	0.189	0.0806	0.11	
55722-27-5	Total TCDF		NA	169/169	100%	0.581	0.0041	11.7	1.17	0.288	0.356	
WHODIOXTEQ(B)	Total WHO Dioxin TEQ(Bird)		NA	169/169	100%	0.142	0.0067	1.59	0.189	0.0836	0.108	
WHODIOXTEQ(F)	Total WHO Dioxin TEQ(Fish)		NA	169/169	100%	0.115	0.00528	1.5	0.169	0.0646	0.0818	
WHODIOXTEQ(H)	Total WHO Dioxin TEQ(Human/Mammal)		NA	169/169	100%	0.115	0.0053	1.5	0.167	0.0647	0.0822	
Inorganics (mg/kg)												
7429-90-5	Aluminum	18000	NJDEP ESC Table - Marine	177/178	99%	12500	0.55	**31500**	5110	10600	13050	Yes
7440-36-0	Antimony	9.3	NJDEP ESC Table - Marine	21/174	12%	2.56	0.235	**35.8**	4.3	1.37	1.25	Yes
7440-38-2	Arsenic	8.2	NJDEP ESC Table - Marine	181/181	100%	**14.4**	1.4	**113**	12.9	11.5	11.4	Yes
7440-39-3	Barium	48	NJDEP ESC Table - Marine	181/181	100%	**146**	9.1	**871**	110	117	123	Yes
7440-41-7	Beryllium		NA	147/178	83%	0.675	0.036	1.6	0.277	0.603	0.69	
7440-43-9	Cadmium	1.2	NJDEP ESC Table - Marine	149/181	82%	**1.84**	0.02	**21.5**	2.54	1.02	1.1	Yes
7440-70-2	Calcium		NA	173/173	100%	7480	345	37800	5100	6300	6940	
7440-47-3	Chromium	81	Recommended by Partner Agencies	258/258	100%	**433**	7	**7430**	877	170	136.5	Yes
7440-48-4	Cobalt	10	NJDEP ESC Table - Marine	165/178	93%	9.31	2.4	**21.8**	3.42	8.59	9.5	Yes
7440-50-8	Copper	13.318	Recommended by Partner Agencies	176/176	100%	**145**	6.8	**781**	122	108	118	Yes
7439-96-5-DIV	Divalent Manganese		NA	20/21	95%	116	12.1	304	72.3	92.6	95.8	
18540-29-9	Hexavalent Chromium		NA	50/84	60%	18	0.2415	951	106	1.91	1.275	
7439-89-6	Iron	20000	USEPA Reg 3 - Freshwater	178/178	100%	**26600**	5310	**57800**	9480	24300	27950	Yes
7439-92-1	Lead	10.606	Recommended by Partner Agencies	207/207	100%	**153**	7	**882**	122	115	120	Yes
7439-95-4	Magnesium		NA	178/178	100%	6800	1250	15400	2610	6130	7230	
7439-96-5	Manganese	260	NJDEP ESC Table - Marine	178/178	100%	**364**	51.6	**790**	149	324	369	Yes
7439-97-6	Mercury	0.037	Recommended by Partner Agencies	203/204	100%	**4.52**	0.04	**77**	9.13	2.18	2.3	Yes
7440-02-0	Nickel	21	NJDEP ESC Table - Marine	178/178	100%	**35.2**	5.7	**179**	18.8	31	34.825	Yes
7440-09-7	Potassium		NA	169/169	100%	2890	298	8440	1500	2390	2960	
7782-49-2	Selenium	1	NJDEP ESC Table - Marine	83/177	47%	**1.16**	0.14	**4.6**	0.952	0.884	0.81	Yes
7440-22-4	Silver	1	NJDEP ESC Table - Marine	142/172	83%	**2.22**	0.08	**15.85**	2.01	1.59	1.7	Yes
7440-23-5	Sodium		NA	178/178	100%	7200	551	25200	4020	5980	6915	
7440-28-0	Thallium		NA	48/174	28%	0.988	0.071	9.60	0.987	0.71	0.75	
7440-32-6	Titanium		NA	106/106	100%	444	116	896	130	423	454	
7440-62-2	Vanadium	57	NJDEP ESC Table - Marine	178/178	100%	35.1	5.8	**98.5**	14.5	31.6	35.975	Yes
7440-66-6	Zinc	6.62	Recommended by Partner Agencies	178/178	100%	**271**	19.2	**1460**	192	218	222.25	Yes
1191-48-6	Dibutyltin		NA	64/97	66%	5.19	0.47	46.5	6.62	3.13	3.2	
78763-54-9	Monobutyltin		NA	0/95	0%	1.53	0.55	3.55	0.617	1.4	1.55	
1461-25-2	Tetrabutyltin		NA	5/97	5%	2.03	0.95	24	2.35	1.76	1.75	
688-73-3	Tributyltin		NA	63/97	65%	5.96	0.85	74	9.85	3.42	3.7	

Table 4-2
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?
REAC-CN	Reactive Cyanide		NA	0/9	0%	14100	10000	20300	3900	13700	14050	
57-12-5	Total Cyanide	100	NJDEP ESC Table - Freshwater	25/103	24%	**285**	50	**4150**	447	200	180	Yes
Pesticides/Herbicides (µg/kg)												
93-76-5	2,4,5-T	12300	USEPA Reg 3 - Freshwater	26/104	25%	273	3.6	3783	449	102	232.5	
93-72-1	2,4,5-TP (Silvex)	675	USEPA Reg 3 - Freshwater	24/94	26%	318	1.6	**3783**	462	146	260	Yes
94-75-7	2,4-D	1273	USEPA Reg 5	18/107	17%	690	5	**9328**	1090	270	600	Yes
94-82-6	2,4-DB		NA	14/86	16%	639	16	7060	872	378	500	
53-19-0	2,4'-DDD		NA	9/37	24%	6.82	2.2	47	9.9	4.75	3.8	
3424-82-6	2,4'-DDE		NA	12/36	33%	8.65	2.2	33	8.76	5.93	3.875	
789-02-6	2,4'-DDT		NA	9/39	23%	4.77	1.3	56	8.48	3.48	3.6	
72-54-8	4,4'-DDD	2	NJDEP ESC Table - Marine	79/196	40%	**23**	1.9	**320**	40	12.8	10.5	Yes
72-55-9	4,4'-DDE	2.2	NJDEP ESC Table - Marine	127/196	65%	**39**	1.9	**1000**	80.5	20.7	22	Yes
50-29-3	4,4'-DDT	1	NJDEP ESC Table - Marine	36/193	19%	**23.4**	1.4	**560**	56.1	9.92	8	Yes
309-00-2	Aldrin	2	Recommended by Partner Agencies	9/195	5%	**7.08**	0.63	**115**	10.4	4.49	4.65	Yes
319-84-6	Alpha-BHC	6	NJDEP ESC Table - Freshwater	16/196	8%	**7.49**	0.59	**115**	10.9	4.46	4.525	Yes
5103-71-9	Alpha-Chlordane	3.24	Recommended by Partner Agencies	37/152	24%	**7.68**	0.39	**115**	11.7	4.39	4.4	Yes
319-85-7	Beta-BHC	5	NJDEP ESC Table - Freshwater	13/192	7%	**7.51**	1	**115**	11.6	4.52	4.6	Yes
5013-74-2	Beta-Chlordane	3.24	NA	11/26	42%	3.33	1	12	2.69	2.55	1.725	
57-74-9	Chlordane	3.24	Recommended by Partner Agencies	0/47	0%	**55.1**	4.15	**100**	20.8	47.7	55	
319-86-8	Delta-BHC	3	NJDEP ESC Table - Freshwater	20/195	10%	**7.13**	1	**115**	10.4	4.58	4.6	Yes
60-57-1	Dieldrin	271	Recommended by Partner Agencies	27/195	14%	12.9	0.67	230	20.7	7.68	6.75	
959-98-8	Endosulfan I	2.9	USEPA Reg 3 - Freshwater	9/196	5%	**7.57**	1	**115**	10.7	4.8	4.725	Yes
33213-65-9	Endosulfan II	14	USEPA Reg 3 - Freshwater	1/196	1%	12.4	1.9	**230**	20.7	7.41	6.5	Yes
1031-07-8	Endosulfan sulfate	34.6	NJDEP ESC Table - Freshwater	14/195	7%	12.5	1.3	**230**	20.8	7.42	6.5	Yes
72-20-8	Endrin	3	Recommended by Partner Agencies	9/199	5%	**12.5**	1	**230**	20.6	7.4	6.5	Yes
7421-93-4	Endrin Aldehyde	480	NJDEP ESC Table - Freshwater	17/196	9%	13.5	1.2	230	22.6	7.83	6.6	
53494-70-5	Endrin Ketone		NA	17/196	9%	14.2	1.4	230	21.7	8.2	7	
58-89-9	Gamma-BHC (Lindane)	3	NJDEP ESC Table - Freshwater	5/198	3%	**6.97**	0.41	**115**	10.3	4.33	4.525	Yes
5566-34-7	Gamma-Chlordane	3.24	Recommended by Partner Agencies	21/122	17%	**9.58**	1.1	**115**	12.5	6.28	5.5	Yes
76-44-8	Heptachlor	0.68	Recommended by Partner Agencies	12/197	6%	**7.37**	0.85	**115**	11.1	4.52	4.65	Yes
1024-57-3	Heptachlor epoxide	5	NJDEP ESC Table - Freshwater	26/195	13%	**8.25**	0.85	**140**	14.1	4.96	4.75	Yes
72-43-5	Methoxychlor	13.6	Recommended by Partner Agencies	10/199	5%	**58.3**	3.8	**1150**	107	26.9	20.5	Yes
TBHC	Total BHC	3	Recommended by Partner Agencies	48/199	24%	**7.99**	0.61	**115**	12	4.64	4.5	Yes
TDDT-24-44	Total DDT (2,4 & 4,4)		NA	39/39	100%	72.7	8.5	520	103	40.6	30	
TDDT-24	Total DDT (2,4)		NA	17/39	44%	13.6	1.3	78	20.5	6.58	4	
TDDT-44	Total DDT (4,4)	1.58	Recommended by Partner Agencies	129/196	66%	**64.9**	1.9	**1100**	134	27.8	28.25	Yes
8001-35-2	Toxaphene	0.077	NJDEP ESC Table - Freshwater	0/199	0%	**443**	8.5	**11500**	1000	212	195	
TOT_AGChlor	Total Alpha + Gamma Chlordane	3.24	Recommended by Partner Agencies	37/126	29%	**10**	0.39	**115**	12.6	6.39	5.5	Yes
PCBs (µg/kg)												
12674-11-2	Aroclor-1016	7	NJDEP ESC Table - Freshwater	0/132	0%	**76.4**	19	**750**	87.2	57.2	45.25	
11104-28-2	Aroclor-1221		NA	0/132	0%	82.5	21.5	750	84.8	65.8	65	
11141-16-5	Aroclor-1232		NA	0/132	0%	76.4	19	750	87.2	57.2	45.25	
53469-21-9	Aroclor-1242		NA	39/132	30%	123	19	1000	147	84.9	90	
12672-29-6	Aroclor-1248	30	NJDEP ESC Table - Freshwater	74/132	56%	**298**	18	**9100**	899	102	100	Yes
11097-69-1	Aroclor-1254	60	NJDEP ESC Table - Freshwater	101/132	77%	**272**	19	**4100**	464	139	150	Yes
11096-82-5	Aroclor-1260	5	NJDEP ESC Table - Freshwater	108/132	82%	**127**	14	**980**	158	83.4	80.5	Yes
37324-23-5	Aroclor-1262		NA	0/106	0%	87.9	21.5	750	93.9	67.4	72.5	
11100-14-4	Aroclor-1268		NA	2/106	2%	87.4	9.8	750	94.2	66.1	72.5	
TOT_PCB_ARO(7)	Total Aroclor PCBs (Sum of 7 Aroclors)	22.7	Recommended by Partner Agencies	116/132	88%	**729**	37	**14000**	1450	358	370	Yes
TOT_PCB_ARO(9)	Total Aroclor PCBs (Sum of 9 Aroclors)	22.7	Recommended by Partner Agencies	104/106	98%	**862**	37	**14000**	1590	472	440	Yes
TPCB Cong-209	Total PCB Congeners (209)	22.7	Recommended by Partner Agencies	106/106	100%	**762**	4.53	**7700**	1020	446	478.25	Yes
TPCB CongNOAA89	Total PCB Congeners (NOAA 1989)		NA	106/106	100%	566	3.05	5520	746	332	353	
WHOPCBTEQ(B)	Total PCB TEQ (Bird)		NA	169/169	100%	0.198	0.004	1.87	0.254	0.114	0.141	
WHOPCBTEQ(F)	Total PCB TEQ (Fish)		NA	169/169	100%	0.00116	0	0.01	0.00141	0.00121	0.001	
WHOPCBTEQ(H)	Total PCB TEQ (Human/Mammal)		NA	169/169	100%	0.0137	0	0.096	0.0143	0.00941	0.011	
25429-29-2	Total Pentachlorobiphenyl		NA	158/158	100%	150	0.321	1290	191	80.9	106.5	
26914-33-0	Total Tetrachlorobiphenyl		NA	158/158	100%	219	0.76	3170	359	106	128	
25323-68-6	Total Trichlorobiphenyl		NA	158/158	100%	131	0.272	2220	233	61.1	82.75	
TriPCB	TriPCB		NA	109/109	100%	721	3.61	7330	963	419	444	

Table 4-2
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?
Semivolatile Organic Compounds (µg/kg)												
95-94-3	1,2,4,5-Tetrachlorobenzene	1252	NJDEP ESC Table - Freshwater	0/38	0%	215	115	850	122	199	190	
120-82-1	1,2,4-Trichlorobenzene	4.8	NJDEP ESC Table - Marine	20/111	18%	**524**	13	**4450**	824	84.7	54	Yes
95-50-1	1,2-Dichlorobenzene	13	NJDEP ESC Table - Marine	11/111	10%	**627**	17	**4450**	790	139	250	Yes
541-73-1	1,3-Dichlorobenzene	1315	NJDEP ESC Table - Freshwater	14/111	13%	619	19	**4450**	794	133	230	Yes
106-46-7	1,4-Dichlorobenzene	110	NJDEP ESC Table - Marine	46/114	40%	**504**	8.8	**4450**	789	102	125	Yes
90-12-0	1-Methylnaphthalene		NA	13/14	93%	46.9	2.5	130	33.6	34.3	42	
540-54-5	2,2-oxybis(1-Chloropropane)		NA	0/149	0%	547	110	4450	696	371	325	
58-90-2	2,3,4,6-Tetrachlorophenol	284	USEPA Reg 3 - Freshwater	0/38	0%	215	115	**850**	122	199	190	Yes
95-95-4	2,4,5-Trichlorophenol	3	NJDEP ESC Table - Marine	0/152	0%	**540**	110	**4450**	691	365	325	
88-06-2	2,4,6-Trichlorophenol	6	NJDEP ESC Table - Marine	0/152	0%	**540**	110	**4450**	691	365	325	
120-83-2	2,4-Dichlorophenol	5	NJDEP ESC Table - Marine	0/149	0%	**547**	110	**4450**	696	371	325	
105-67-9	2,4-Dimethylphenol	304	NJDEP ESC Table - Freshwater	1/149	1%	**545**	100	**4450**	697	367	325	Yes
51-28-5	2,4-Dinitrophenol	6.21	NJDEP ESC Table - Freshwater	0/149	0%	**2490**	220	**22500**	3660	1360	1350	
121-14-2	2,4-Dinitrotoluene	14.4	NJDEP ESC Table - Freshwater	0/152	0%	**459**	38	**4450**	714	229	195	
606-20-2	2,6-Dinitrotoluene	39.8	USEPA Reg 5	0/149	0%	**465**	38	**4450**	720	230	200	
91-58-7	2-Chloronaphthalene	417	NJDEP ESC Table - Freshwater	0/149	0%	**547**	110	**4450**	696	371	325	
95-57-8	2-Chlorophenol	8	NJDEP ESC Table - Marine	0/149	0%	**547**	110	**4450**	696	371	325	
91-57-6	2-Methylnaphthalene	70	NJDEP ESC Table - Marine	111/164	68%	**366**	6.6	**4450**	679	148	105	Yes
95-48-7	2-Methylphenol	55.4	USEPA Reg 5	0/152	0%	**540**	110	**4450**	691	365	325	
88-74-4	2-Nitroaniline		NA	0/149	0%	701	110	4450	700	538	485	
88-75-5	2-Nitrophenol		NA	0/149	0%	547	110	4450	696	371	325	
108-39-4/106-44	3&4-Methylphenol	670	USEPA Reg 3 - Freshwater	0/3	0%	165	165	165	0	165	165	
91-94-1	3,3'-Dichlorobenzidine	127	NJDEP ESC Table - Freshwater	0/149	0%	**1040**	115	**9000**	1430	621	650	
99-09-2	3-Nitroaniline		NA	0/149	0%	1090	215	9000	1400	735	650	
534-52-1	4,6-Dinitro-2-methylphenol	104	USEPA Reg 5	0/149	0%	**1690**	220	**14000**	2140	1080	1150	
101-55-3	4-Bromophenyl phenyl ether	1230	USEPA Reg 3 - Freshwater	0/109	0%	616	110	**4450**	790	392	395	
59-50-7	4-Chloro-3-Methylphenol	388	USEPA Reg 5	0/149	0%	**547**	110	**4450**	696	371	325	
106-47-8	4-Chloroaniline	146	USEPA Reg 5	45/149	30%	**436**	12	**4450**	640	248	225	Yes
7005-72-3	4-Chlorophenyl phenyl ether		NA	0/149	0%	547	110	4450	696	371	325	
106-44-5	4-Methylphenol	670	USEPA Reg 3 - Freshwater	37/149	25%	474	8.8	**4450**	716	235	210	Yes
100-01-6	4-Nitroaniline		NA	0/149	0%	1090	215	9000	1400	735	650	
100-02-7	4-Nitrophenol	13.3	NJDEP ESC Table - Freshwater	0/149	0%	**1690**	220	**14000**	2140	1080	1150	
83-32-9	Acenaphthene	16	NJDEP ESC Table - Marine	120/180	67%	**614**	7.9	**11000**	1210	210	180	Yes
208-96-8	Acenaphthylene	44	NJDEP ESC Table - Marine	164/180	91%	**454**	8.6	**4950**	741	235	230	Yes
98-86-2	Acetophenone		NA	6/38	16%	211	56	850	138	183	190	
120-12-7	Anthracene	85	NJDEP ESC Table - Marine	171/179	96%	**737**	18	**7400**	1130	408	380	Yes
1912-24-9	Atrazine	6.62	USEPA Reg 3 - Freshwater	0/38	0%	**215**	115	**850**	122	199	190	
100-52-7	Benzaldehyde		NA	14/38	37%	166	34	850	133	133	172.5	
56-55-3	Benzo(a)anthracene	261	NJDEP ESC Table - Marine	179/179	100%	**1590**	34	**20000**	2320	966	910	Yes
50-32-8	Benzo(a)pyrene	430	NJDEP ESC Table - Marine	179/179	100%	**1560**	29	**15000**	1820	1060	1000	Yes
205-99-2	Benzo(b)fluoranthene	1800	NJDEP ESC Table - Marine	179/179	100%	1630	19	**23000**	2320	1050	1000	Yes
192-97-2	Benzo(e)pyrene		NA	14/14	100%	812	53	1400	393	651	820	
191-24-2	Benzo(g,h,i)perylene	170	NJDEP ESC Table - Freshwater	178/179	99%	**754**	16	**7400**	830	519	510	Yes
207-08-9	Benzo(k)fluoranthene	240	NJDEP ESC Table - Freshwater	176/179	98%	**1230**	27	**16000**	1580	802	770	Yes
92-52-4	Biphenyl	1220	USEPA Reg 3 - Freshwater	16/52	31%	155	1.7	850	141	86.5	172.5	
111-91-1	bis(2-Chloroethoxy)methane		NA	0/149	0%	547	110	4450	696	371	325	
111-44-4	bis(2-Chloroethyl)ether	3520	NJDEP ESC Table - Freshwater	1/149	1%	455	19	**4450**	725	190	195	Yes
117-81-7	bis(2-ethylhexyl phthalate)	182.16	Recommended by Partner Agencies	144/149	97%	**5830**	80	**71000**	10600	2540	2700	Yes
85-68-7	Butyl benzyl phthalate	63	NJDEP ESC Table - Marine	38/149	26%	**511**	38	**4450**	697	302	325	Yes
105-60-2	Caprolactam		NA	1/38	3%	213	115	850	123	197	190	
86-74-8	Carbazole		NA	82/149	55%	430	8.7	4450	761	172	170	
218-01-9	Chrysene	384	NJDEP ESC Table - Marine	179/179	100%	**1970**	29	**45000**	3930	1130	1035	Yes
53-70-3	Dibenzo(a,h)anthracene	63	NJDEP ESC Table - Marine	143/179	80%	**389**	9.6	**4950**	706	198	180	Yes
132-64-9	Dibenzofuran	7300	USEPA Reg 3 - Marine	84/163	52%	426	2.5	4450	719	173	150	
132-65-0	Dibenzothiophene		NA	13/14	93%	76.8	2.5	210	67.3	49.3	56	
84-66-2	Diethyl phthalate	6	NJDEP ESC Table - Marine	1/149	1%	**547**	110	**4450**	696	371	325	Yes
131-11-3	Dimethylphthalate		NA	0/149	0%	547	110	4450	696	371	325	
84-74-2	Di-n-Butylphthalate	58	NJDEP ESC Table - Marine	17/149	11%	**634**	37	**5100**	892	379	335	Yes
117-84-0	Di-n-Octylphthalate	40600	USEPA Reg 5	16/141	11%	580	47	4450	742	376	380	
206-44-0	Fluoranthene	600	NJDEP ESC Table - Marine	179/179	100%	**3840**	34	**210000**	16000	1550	1400	Yes
86-73-7	Fluorene	19	NJDEP ESC Table - Marine	123/180	68%	**453**	5.6	**4950**	813	181	155	Yes

Table 4-2
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?
118-74-1	Hexachlorobenzene	20	Recommended by Partner Agencies	7/153	5%	**396**	1.6	**4450**	736	76.9	55	Yes
87-68-3	Hexachlorobutadiene	1.3	NJDEP ESC Table - Marine	0/152	0%	**459**	38	**4450**	714	229	195	
77-47-4	Hexachlorocyclopentadiene	901	NJDEP ESC Table - Freshwater	0/118	0%	**1620**	135	**14000**	2390	810	850	
67-72-1	Hexachloroethane	73	NJDEP ESC Table - Marine	0/152	0%	**449**	19	**4450**	719	187	192.5	
193-39-5	Indeno(1,2,3-cd)pyrene	200	NJDEP ESC Table - Freshwater	174/179	97%	**718**	13	**6300**	787	486	490	Yes
78-59-1	Isophorone	432	NJDEP ESC Table - Freshwater	0/149	0%	**547**	110	**4450**	696	371	325	
91-20-3	Naphthalene	160	NJDEP ESC Table - Marine	141/180	78%	**600**	18	**6400**	1010	272	230	Yes
98-95-3	Nitrobenzene	145	NJDEP ESC Table - Freshwater	3/152	2%	**451**	19	**4450**	718	191	195	Yes
621-64-7	N-Nitroso-di-n-propylamine		NA	0/149	0%	455	19	4450	725	188	195	
86-30-6	N-Nitrosodiphenylamine	422000	USEPA Reg 3 - Marine	6/149	4%	519	73	4450	668	355	325	
87-86-5	Pentachlorophenol	17	NJDEP ESC Table - Marine	0/153	0%	**1580**	4.7	**14000**	2180	455	1100	
198-55-0	Perylene		NA	14/14	100%	322	23	600	149	262	325	
85-01-8	Phenanthrene	240	NJDEP ESC Table - Marine	173/179	97%	**1080**	25	**31000**	3090	499	440	Yes
108-95-2	Phenol	130	NJDEP ESC Table - Marine	5/149	3%	**533**	110	**4450**	694	359	325	Yes
129-00-0	Pyrene	665	NJDEP ESC Table - Marine	179/179	100%	**3770**	65	**150000**	11500	1930	1800	Yes
110-86-1	Pyridine	106	USEPA Reg 5	0/3	0%	**850**	850	**850**	0	850	850	
THMW PAHs-SVOC	Total HMW PAHs-SVOC	1700	Recommended by Partner Agencies	179/180	99%	**17100**	0	**470000**	38100	9930	9500	Yes
TLMW PAHs-SVOC	Total LMW PAHs-SVOC	552	Recommended by Partner Agencies	160/164	98%	**2700**	8.6	**44000**	5460	1380	1325	Yes
TOT_PAH_SVOC	TOTAL PAHs - SVOC	4000	Recommended by Partner Agencies	164/164	100%	**19300**	290	**520000**	44500	10800	11000	Yes
TEPH	TEPH		NA	67/67	100%	1340000	67000	9700000	1610000	843000	930000	
TPH	Total Petroleum Hydrocarbons		NA	39/39	100%	1220000	280000	5400000	1020000	982000	900000	
Volatile Organic Compounds (µg/kg)												
71-55-6	1,1,1-Trichloroethane	213	NJDEP ESC Table - Freshwater	0/67	0%	14	3	**450**	54.2	7.12	7	
79-34-5	1,1,2,2-Tetrachloroethane	850	NJDEP ESC Table - Freshwater	0/66	0%	14.1	3	450	54.6	7.13	7	
79-00-5	1,1,2-Trichloroethane	518	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	
75-34-3	1,1-Dichloroethane	0.575	USEPA Reg 5	0/67	0%	**14**	3	**450**	54.2	7.12	7	
75-35-4	1,1-Dichloroethene	19.4	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	**450**	53.1	6.8	6.625	
87-61-6	1,2,3-Trichlorobenzene	858	USEPA Reg 3 - Freshwater	0/38	0%	9.43	4.85	14.5	2.34	9.14	9.5	
120-82-1	1,2,4-Trichlorobenzene	4.8	NJDEP ESC Table - Marine	0/38	0%	**9.43**	4.85	**14.5**	2.34	84.7	54	
95-50-1	1,2-Dichlorobenzene	13	NJDEP ESC Table - Marine	0/38	0%	9.43	4.85	**14.5**	2.34	139	250	
107-06-2	1,2-Dichloroethane	260	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	**450**	53.1	6.8	6.625	
540-59-0	1,2-Dichloroethene (total)	654	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	
78-87-5	1,2-Dichloropropane	333	NJDEP ESC Table - Freshwater	0/67	0%	14	3	**450**	54.2	7.12	7	
541-73-1	1,3-Dichlorobenzene	1315	NJDEP ESC Table - Freshwater	0/38	0%	9.43	4.85	14.5	2.34	133	230	
106-46-7	1,4-Dichlorobenzene	110	NJDEP ESC Table - Marine	2/38	5%	9.32	4.85	14.5	2.24	102	125	
78-93-3	2-Butanone	42.4	USEPA Reg 5	19/35	54%	**51.6**	7	**900**	150	21.9	16	Yes
591-78-6	2-Hexanone	58.2	USEPA Reg 5	0/67	0%	27.9	5.5	**900**	108	14.2	13.5	
108-10-1	4-Methyl-2-pentanone	25.1	USEPA Reg 5	0/67	0%	**27.9**	5.5	**900**	108	14.2	13.5	
67-64-1	Acetone	9.9	USEPA Reg 5	66/66	100%	**85.4**	8	**580**	101	54.6	51.5	Yes
71-43-2	Benzene	340	NJDEP ESC Table - Marine	7/70	10%	13.1	0.67	**450**	53.1	6.32	6.25	Yes
75-27-4	Bromodichloromethane		NA	0/67	0%	14	3	450	54.2	7.12	7	
75-25-2	Bromoform	492	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	
74-83-9	Bromomethane	1.37	NJDEP ESC Table - Freshwater	0/67	0%	**14**	3	**450**	54.2	7.12	7	
75-15-0	Carbon disulfide	0.851	USEPA Reg 3 - Freshwater	44/67	66%	**19.1**	2	**450**	57.1	8.2	7	Yes
56-23-5	Carbon tetrachloride	1450	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	
108-90-7	Chlorobenzene	291	NJDEP ESC Table - Freshwater	24/108	22%	13.5	2.5	**450**	43.2	7.82	7	Yes
75-00-3	Chloroethane		NA	0/67	0%	14	3	450	54.2	7.12	7	
67-66-3	Chloroform	121	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	**450**	53.1	6.8	6.625	
74-87-3	Chloromethane		NA	0/67	0%	14	3	450	54.2	7.12	7	
10061-01-5	cis-1,3-Dichloropropene		NA	0/67	0%	14	3	450	54.2	7.12	7	
124-48-1	Dibromochloromethane		NA	0/67	0%	14	3	450	54.2	7.12	7	
100-41-4	Ethylbenzene	1400	NJDEP ESC Table - Marine	2/67	3%	14.3	2	450	54.3	7.14	7	
75-09-2	Methylene chloride	159	NJDEP ESC Table - Freshwater	0/67	0%	14	3	**450**	54.2	7.12	7	

Table 4-2
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?
100-42-5	Styrene	254	NJDEP ESC Table - Freshwater	0/67	0%	14	3	**450**	54.2	7.12	7	
127-18-4	Tetrachloroethene	450	NJDEP ESC Table - Marine	1/70	1%	13.4	2.5	450	53.1	6.75	6.625	
108-88-3	Toluene	2500	NJDEP ESC Table - Marine	5/67	7%	14.7	3	450	54.6	7.13	6.75	
10061-02-6	trans-1,3-Dichloropropene	7.31	USEPA Reg 3 - Marine	0/67	0%	**14**	3	**450**	54.2	7.12	7	
79-01-6	Trichloroethene	1600	NJDEP ESC Table - Marine	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	
75-01-4	Vinyl chloride	202	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	**450**	53.1	6.8	6.625	
1330-20-7	Xylene (Total)	120	NJDEP ESC Table - Marine	3/67	4%	14.7	3	**450**	54.4	7.4	7	Yes

Notes:
A value of one-half the detection limit is used for non-detects in the dataset and in the summary statistics above.
Bold and shaded cells indicate detected concentrations exceed screening values.
Bold values indicate non-detected concentrations exceed screening values.
Data from Phase I and Phase II Sediment Investigations (Tierra 2010) and Honeywell International Sampling Investigation (2006)

Acronyms and Abbreviations:
COPEC = constituent of potential ecological concern
NJDEP ESC = New Jersey Department of Environmental Protection Ecological Screening Criteria
NA = not available
USEPA = United States Environmental Protection Agency
μg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

Screening Values:
Recommended by Partner Agencies: Ecological sediment screening levels for saline waters —as recommended by the Partner Agencies for the Lower Passaic River in email correspondence to Scott Kirchner of CDM dated May 26, 2011.
NJDEP ESC Table - Marine: NJDEP Ecological Screening Criteria (ESC) for Marine Sediment. March 2009.
NJDEP ESC Table - Freshwater: NJDEP Ecological Screening Criteria (ESC) for Freshwater Sediment. March 2009.
USEPA Reg 3 - Marine: USEPA Region 3 Marine Sediment Screening Benchmarks. July 2006.
USEPA Reg 3 - Freshwater: USEPA Region 3 Freshwater Sediment Screening Benchmarks. August 2006.
USEPA Reg 5: USEPA Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels. August 2003.

Sources:
Honeywell. 1999-2006 . *Offshore Investigation Results Summary Report.*
Tierra. 2010a. *Phase I and Phase II Data Evaluation and Analysis Report. Newark Bay Study Area Remedial Investigation.* Revision 0. Tierra Solutions, Inc., East Brunswick, New Jersey. April.

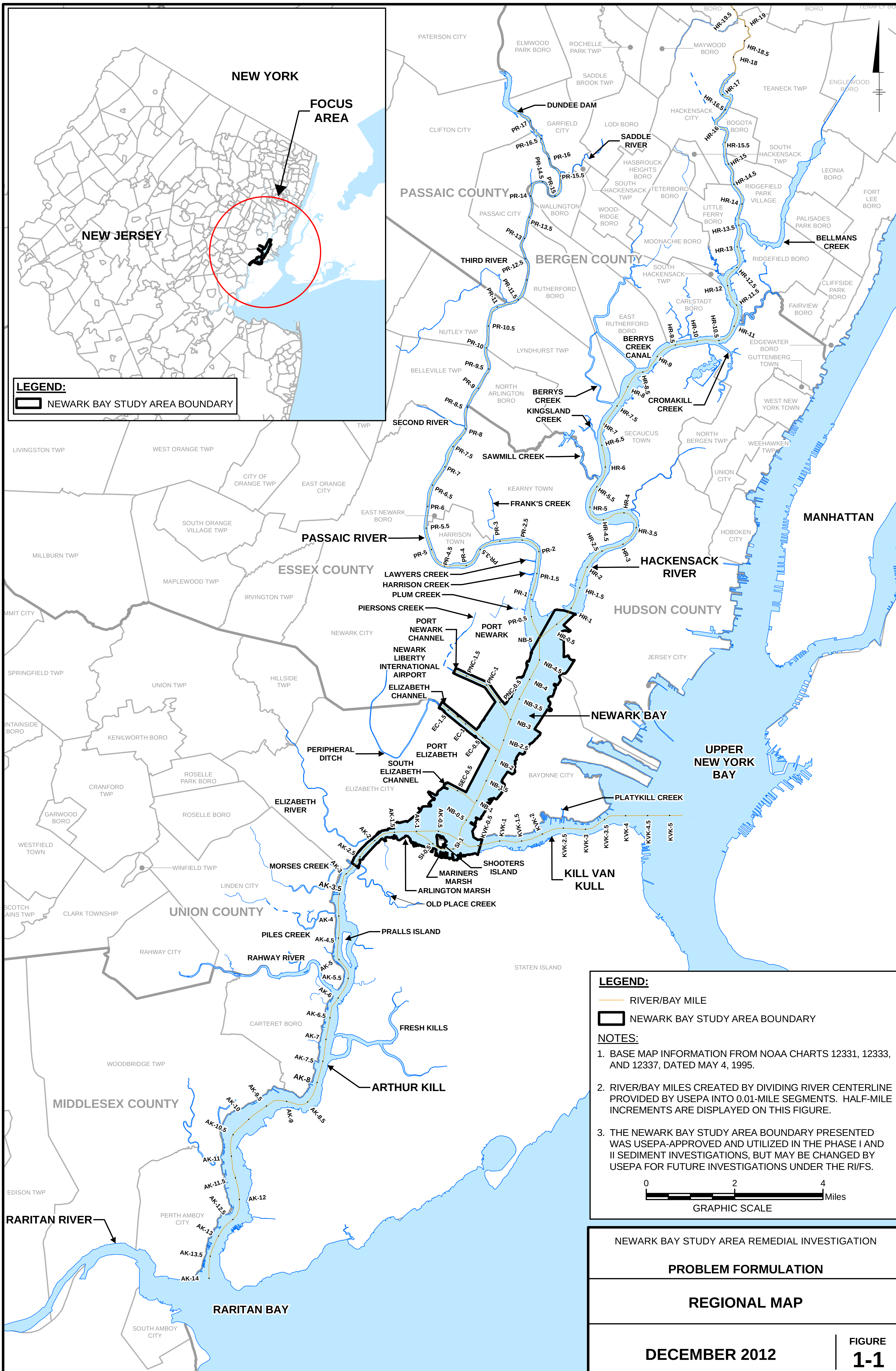
Table 4-3
Assessment Endpoints, Measurement Endpoints, and Data to be Collected for the NBSA BERA

Receptor Group and Assessment Endpoint	Testable Hypothesis	Description of Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled	Background Evaluation?	Number/Seasonality of Proposed Samples
Assessment Endpoint No. 1 - Survival and growth of aquatic plants as a food resource and habitat for fish and wildlife	Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival and growth of aquatic plants?	Chemical concentrations in sediment and surface water collected from relevant exposure areas as compared with available and relevant toxicity-based screening benchmarks (i.e., aquatic thresholds)	Estimating the exposure of plants via direct contact and uptake of chemicals in surface water and sediment	Surface water and surficial sediment chemistry and conventional parameters from relevant exposure areas	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 2 - Survival, growth, and reproduction of invertebrates	Are invertebrate communities in the NBSA different from those found in similar nearby water bodies with chemical concentrations at regional background levels?	Community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) and ecosystem characteristics data (e.g., grain size, TOC, and other attributes) from Newark Bay as compared with appropriate urban regional background datasets using diversity indices, multivariate, and spatial statistical techniques	Evaluating the data in the context of the overall health of the benthic community using the sediment quality triad (SQT) approach, a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics	Benthic invertebrate taxonomic survey and identification data	Urban regional background datasets	Exact sample size and frequency TBD with USEPA
	Are COPEC residues in invertebrate tissues from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of invertebrates?	Chemical concentrations in laboratory-exposed and/or site-collected invertebrate tissues (e.g., *Nereis virens, Crassostrea virginica*) as compared with literature-based critical body residue values	Assessing the adverse effects of chemicals on the invertebrate community and using this information to develop a food web model for upper trophic-level organisms	Whole-body benthic infaunal invertebrate tissue from 28-day laboratory and/or field bioaccumulation tests using NBSA surface sediment	None	Exact sample size and frequency TBD with USEPA
	Are COPEC concentrations in NBSA sediments from the BAZ at levels that might cause an adverse effect on survival, growth, and/or reproduction of the invertebrate community?	Chemical concentrations in sediment as compared with toxicity-based sediment benchmarks from the literature	Evaluating the effects of chemical concentrations in sediment on the benthic invertebrate community of the NBSA	Surficial sediment (from the biologically active zone [BAZ]) chemistry and conventional parameters	None	Exact sample size and frequency TBD with USEPA
		Laboratory toxicity tests (e.g., a 10-day survival and growth study with *Ampelisca abdita*, a 28-day study with *Leptocheirus plumulosus* for survival, growth, and reproduction; and a caged *in situ* study with eastern oyster for reproduction) using NBSA surface sediment statistically compared to bioassays conducted with control sediment	Assessing the adverse effects of chemicals (and evaluation of conventional parameters such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community	Surficial sediment (from the BAZ) chemistry and conventional parameters	Urban regional background datasets	Exact sample size and frequency TBD with USEPA
	Are COPEC concentrations in pore water and surface water from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of invertebrates?	Dissolved chemical concentrations in pore and surface water collected from benthic invertebrate exposure areas as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of the benthic invertebrate community via the surface water exposure pathway to chemicals in surface water	Surface water collected from two depth intervals (one sample from near the sediment-water interface and one sample from 2 feet below the water's surface)	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 3 - Survival, growth, and reproduction of fish	Are COPEC concentrations in fish tissue from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish that use the NBSA?	Whole-body chemical analyses, liver tissue chemical analyses, and external health observations of identified fish receptors as compared with literature-based critical body residues and/or with whole-body fish tissue chemical concentrations of selected receptors from background locations	Providing general information about the health of NBSA fish populations	Whole-body fish tissue chemical concentrations, liver chemical concentrations, gross histological analysis, and gross histology of representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory)	Representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory) from background locations	Exact sample size and frequency TBD with USEPA
	Are COPEC concentrations in pore water, surface water, and sediment from the NBSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish?	Chemical concentrations in dissolved pore water and surface water collected from the NBSA as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of fish via the surface water exposure pathway to chemicals in surface water	Data (chemical and conventional parameters such as DO, salinity, pH, hardness) collected as part of the surface water monitoring program	None	Exact sample size and frequency TBD with USEPA
		Chemical concentrations in sediment as compared with toxicity-based sediment benchmarks from the literature	Evaluating the effects of chemical concentrations in sediment on fish populations in the NBSA	Surface sediment collected from the BAZ	None	Exact sample size and frequency TBD with USEPA
		Reproductive health of fish collected from both the NBSA and a reference location assessed via morphology and/or biomarkers (e.g., GSI, gonad condition and fecundity estimates, and vitellogenin) and/or laboratory reproductive bioassays using mummichog or white perch	Evaluating the potential effects of chemical constituents on reproduction of NBSA fish	Fish collected from the NBSA	Fish collected from a background location	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 4 - Survival, growth, and reproduction of birds	Are modeled dietary doses of COPECs based on NBSA biota, sediment, and surface water at levels that might cause an adverse effect on survival, growth, and/or reproduction of birds that use the NBSA?	Receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue as compared with literature-based dietary dose toxicity reference values (TRVs)	Estimating exposure of bird receptors via various exposure pathways to chemicals in surface water, sediment, and prey tissue	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 5 - Survival, growth, and reproduction of mammals	Are modeled dietary doses of COPECs based on NBSA biota, sediment, and surface water at levels that might cause an adverse effect on survival, growth, and/or reproduction of aquatic and semi-aquatic mammals that use the NBSA?	Receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue as compared with literature-based dietary dose TRVs	Estimating exposure of aquatic and semi-aquatic mammals to chemicals in NBSA surface water, sediment, and prey tissue	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet	None	Exact sample size and frequency TBD with USEPA

Acronyms and Abbreviations:
BAZ = biologically active zone
COPEC = constituent of potential ecological concern
DO = dissolved oxygen
GSI = gonadosomatic index
NBSA = Newark Bay Study Area
SQT = sediment quality triad
TBD = to be determined
TOC = total organic carbon
TRV = toxicity reference value
USEPA = US Environmental Protection Agency

Figures

City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: bdeclercq
Newark Bay (B0009989.0017.00005)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\NBRegionalMap.mxd 12/5/2012 12:28:31 PM



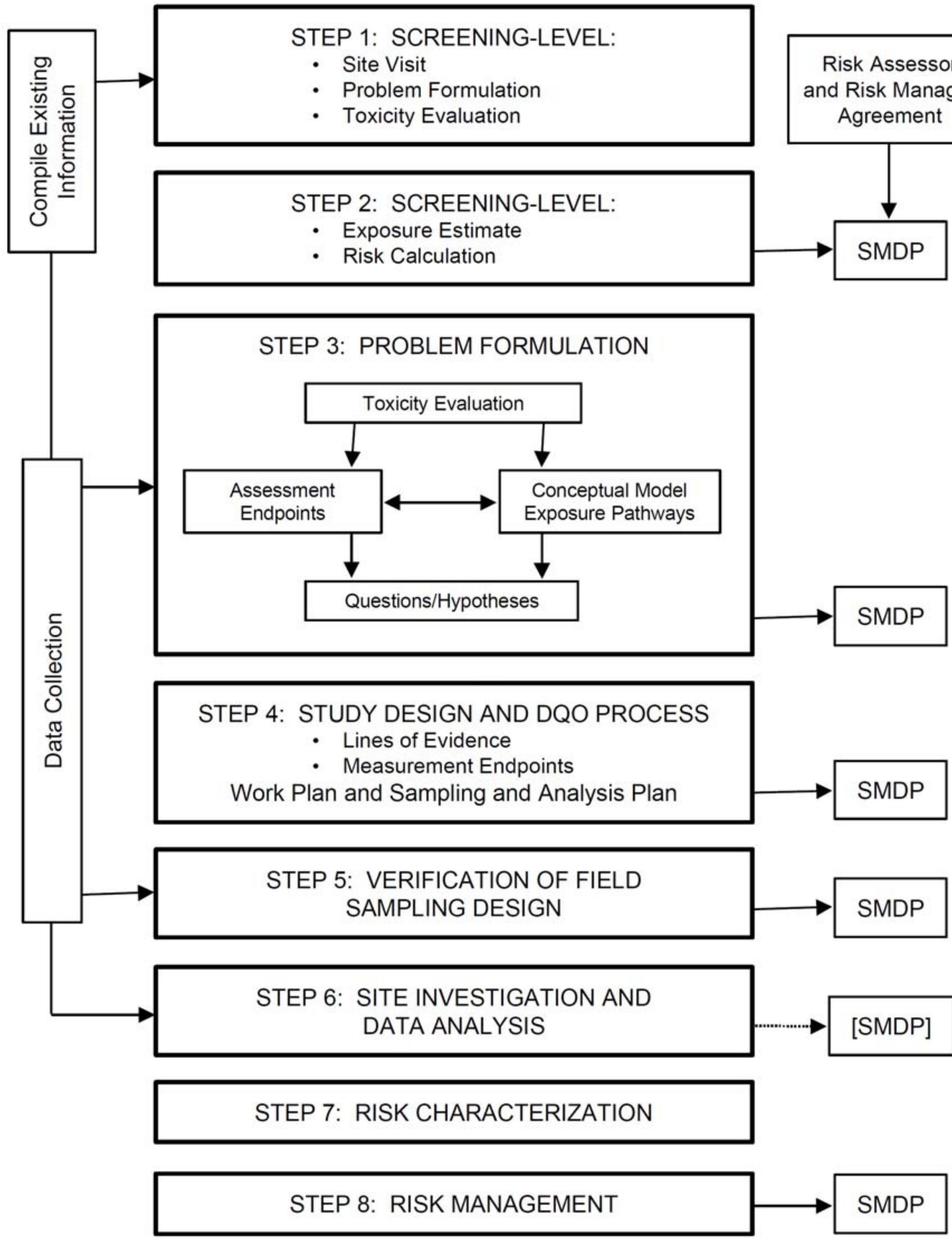
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

PROBLEM FORMULATION

REGIONAL MAP

DECEMBER 2012

FIGURE 1-1



SMDP = Scientific Management Decision Point

[SMDP] = only if change to the sampling and analysis plan is necessary

DQO = Data Quality Objective

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

EIGHT-STEP ECOLOGICAL RISK ASSESSMENT PROCESS FOR SUPERFUND (USEPA 1997)

DECEMBER 2012

FIGURE **1-2**

07/16/2012 SYRACUSE, NY-ENV/CAD DJHOWES
B0009989/0011/00001/CDR/09989G02.CDR

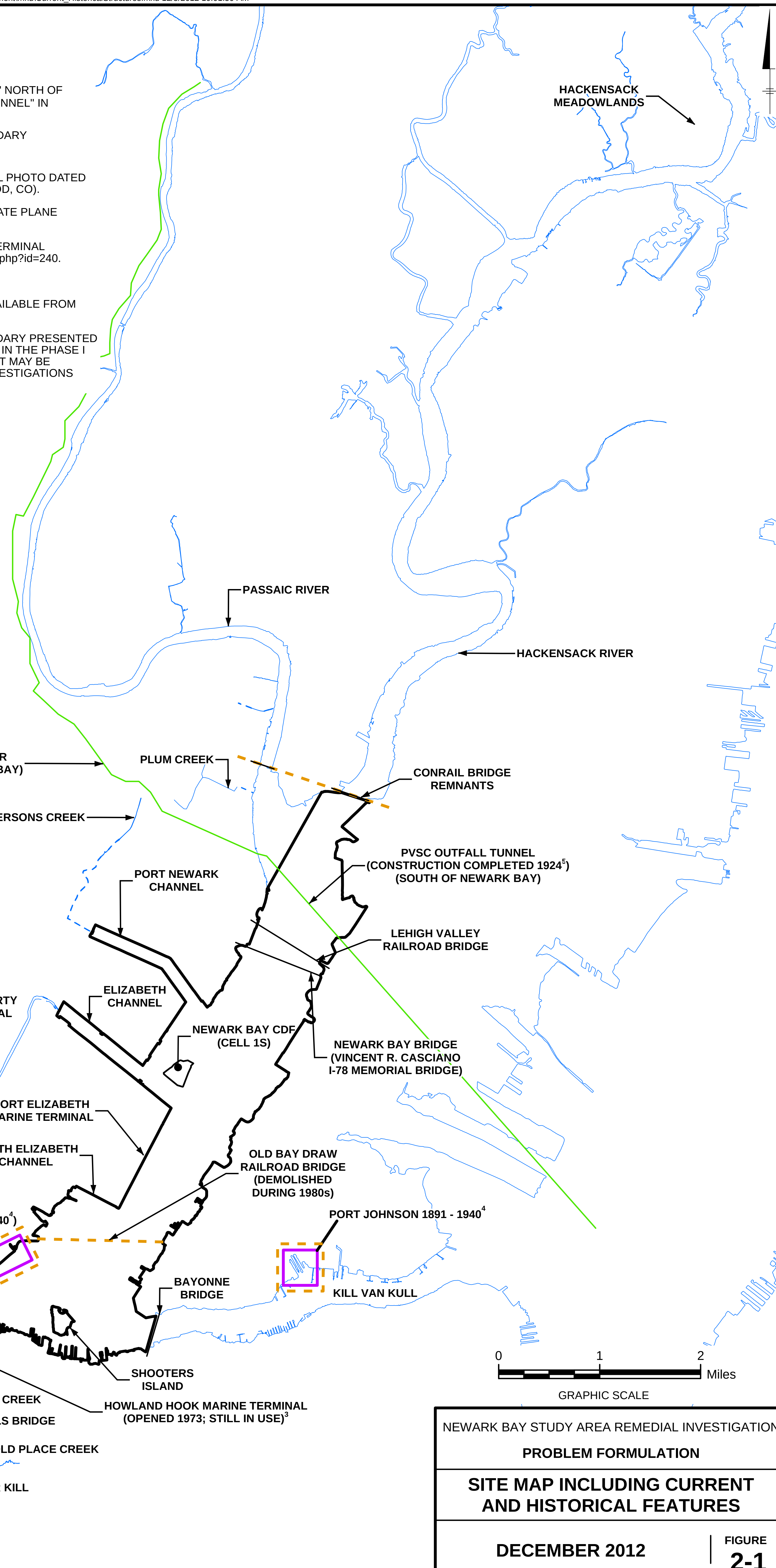
City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: bdeclercq
Newark Bay (B0009989.0017.00005)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\Current_HistoricalStructures.mxd 12/5/2012 10:01:50 AM

LEGEND:

- SHORELINE
- UNDERGROUND TRIBUTARY
- HISTORICAL FEATURE
- PVSC LINE ("PVSC INTERCEPTOR" NORTH OF NEWARK BAY, "PVSC OUTFALL TUNNEL" IN NEWARK BAY AND SOUTH)
- NEWARK BAY STUDY AREA BOUNDARY

NOTES:

1. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
2. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD 83.
3. DATE FROM NEW YORK CONTAINER TERMINAL HISTORY. www.nycterminal.com/t3/index.php?id=240.
4. DATE FROM USACE (2006b).
5. DATES AND TUNNEL INFORMATION AVAILABLE FROM www.nj.gov/pvsc.
6. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.



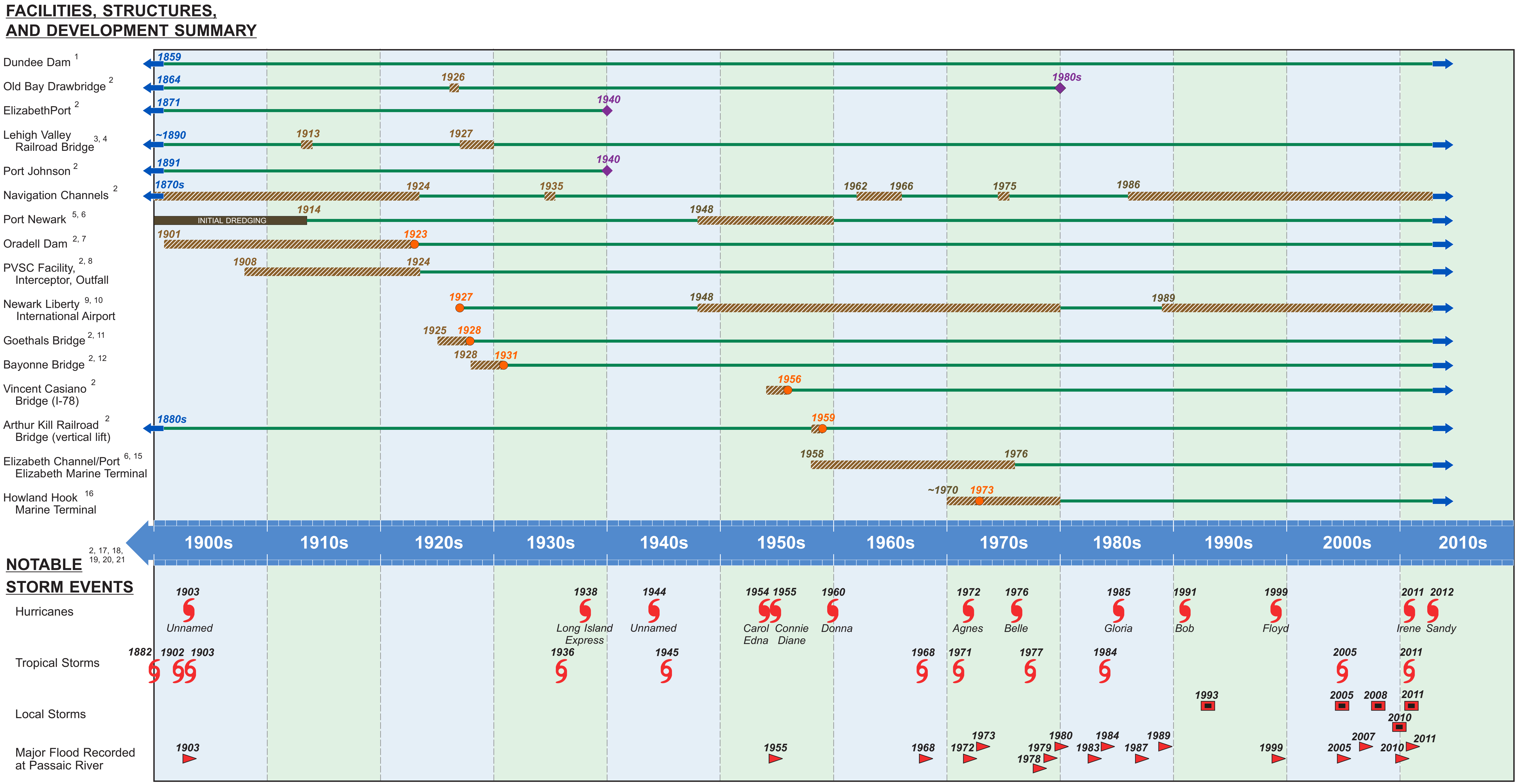
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

PROBLEM FORMULATION

SITE MAP INCLUDING CURRENT AND HISTORICAL FEATURES

DECEMBER 2012

FIGURE **2-1**



NOTES:

1. NEW YORK TIMES (NYT). 1999.
2. U.S. ARMY CORPS OF ENGINEERS (USACE). 2006b.
3. NYT. 1891.
4. NYT. 1913a; 1913b; 1927a; 1927b.
5. NYT. 1926.
6. PANYNJ. 2012a.
7. NYT. 2011.
8. PASSAIC VALLEY SEWERAGE COMMISSION (PVSC). 2011.
9. NYT. 1927c; 1927d.
10. PANYNJ. 2012b.
11. PANYNJ. 2012c.
12. PANYNJ. 2012d.
13. NYT. 1955
14. EASTERN ROADS, 2012.
15. NYT. 1972.
16. NEW YORK CONTAINER TERMINAL (NYCT). 2011.
17. USACE. 2012.
18. NOAA. 2011.
19. HURRICANES SHOWN THAT WERE LISTED AS IMPACTING THE STATES OF NEW YORK AND/OR NEW JERSEY IN NOAA 2007.
20. TROPICAL STORMS AND LOCAL STORMS IDENTIFIED IN USACE 2006.
21. PASSAIC RIVER FLOODS LISTED ARE DEFINED AS "MAJOR" FLOODS ACCORDING TO NOAA 2011.

LEGEND:

- Opened
- Construction/Development Activities
- Demolished
- In Use/Maintained
- Hurricane
- Tropical Storm/Extra-Tropical Storm
- Local Storm
- Major Flood

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

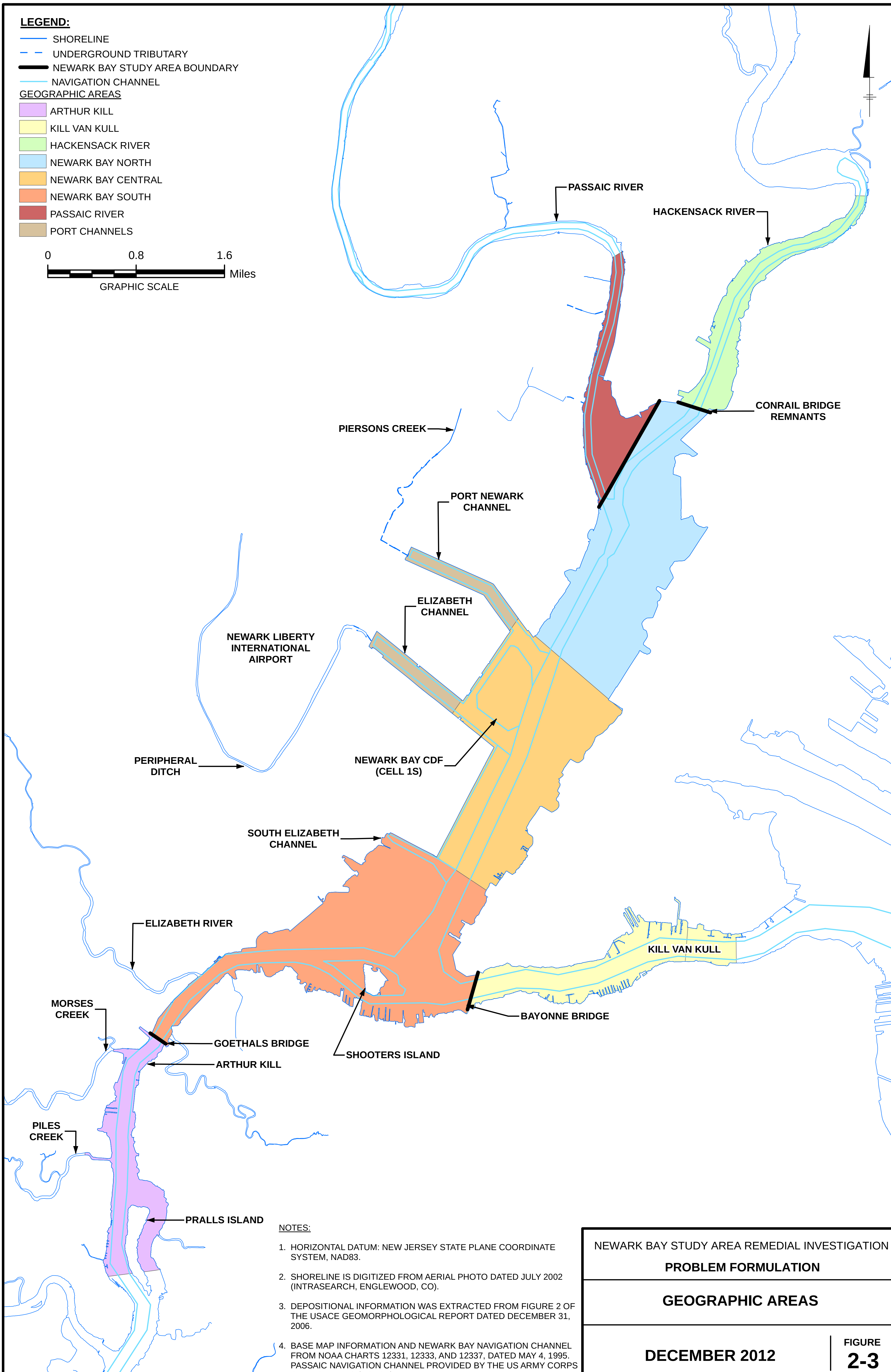
TIMELINE SUMMARY OF NBSA ACTIVITIES

DECEMBER 2012

FIGURE **2-2**

12/07/2012 SYRACUSE, NY-ENV/CAD DJHOWES
B0009989/0017/00002/CDR/09989F01.CDR

CITY: SYR DIV/GROUP: SYE40 DB: K. SINSABAUGH PM:
Newark Bay (B0009989.0011.00001)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\PotentialGeoBounds.mxd - 12/5/2012 @ 4:25:28 PM



NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. DEPOSITIONAL INFORMATION WAS EXTRACTED FROM FIGURE 2 OF THE USACE GEOMORPHOLOGICAL REPORT DATED DECEMBER 31, 2006.
4. BASE MAP INFORMATION AND NEWARK BAY NAVIGATION CHANNEL FROM NOAA CHARTS 12331, 12333, AND 12337, DATED MAY 4, 1995. PASSAIC NAVIGATION CHANNEL PROVIDED BY THE US ARMY CORPS OF ENGINEERS (USACE).

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

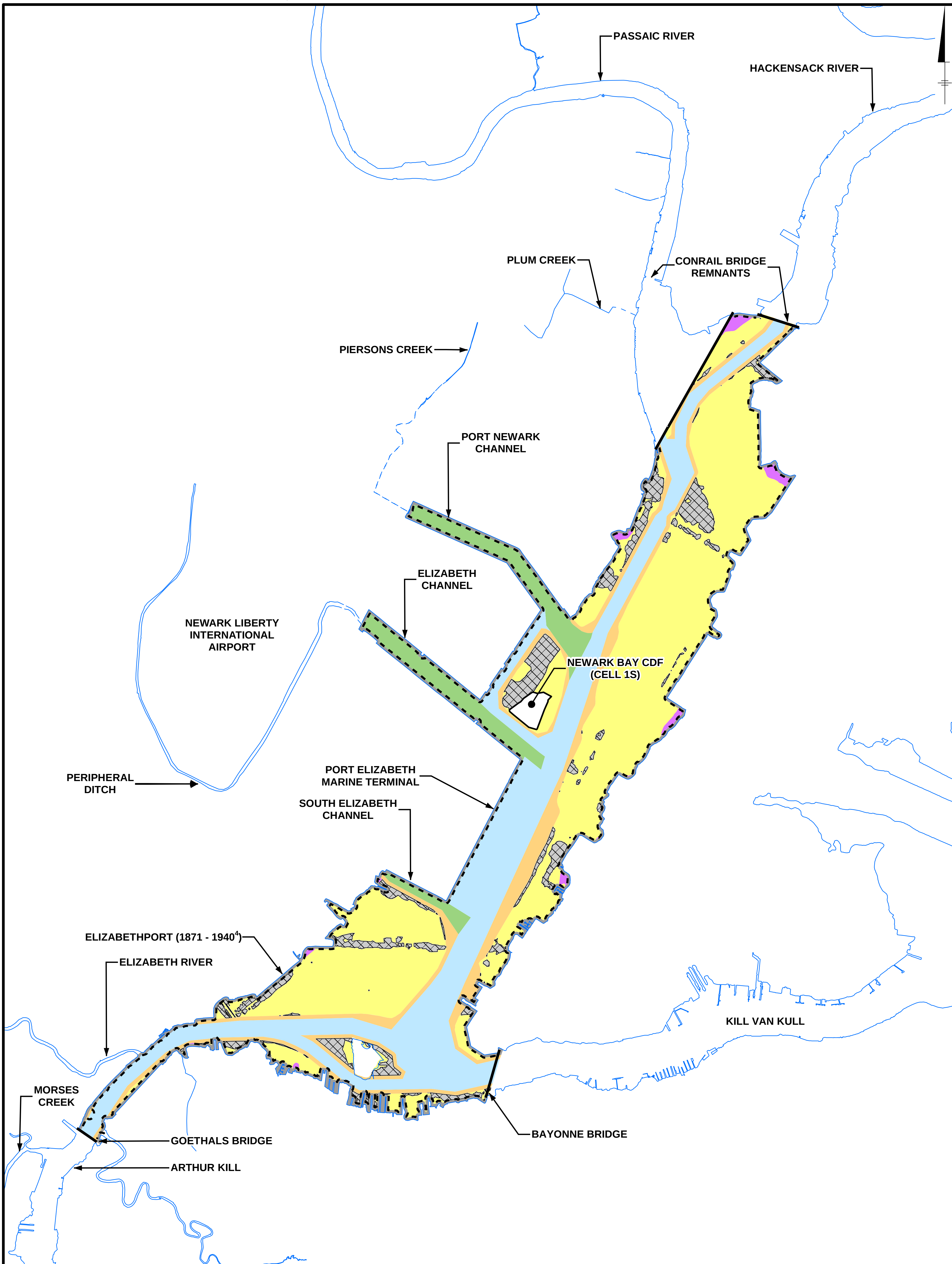
PROBLEM FORMULATION

GEOGRAPHIC AREAS

DECEMBER 2012

FIGURE
2-3

City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: bdeclercq
Newark Bay (B0009989.0017.00005)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\GeomorphicAreas.mxd 12/5/2012 12:25:25 PM



LEGEND:

- SHORELINE
- NEWARK BAY STUDY AREA BOUNDARY
- HISTORICALLY DISTURBED SUBTIDAL FLATS
- INDUSTRIAL WATERFRONT AREA
- INTERTIDAL AREAS
- NAVIGATION CHANNELS
- PORT CHANNELS
- SUBTIDAL FLATS
- TRANSITIONAL SLOPES

NOTES:

1. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
2. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD 83.
3. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.
4. HISTORICALLY DISTURBED SUBTIDAL FLAT AREAS BASED ON THE USACE GEOMORPHOLOGICAL REPORT DATED DECEMBER 31, 2006.

0 3,500 7,000 Feet

GRAPHIC SCALE

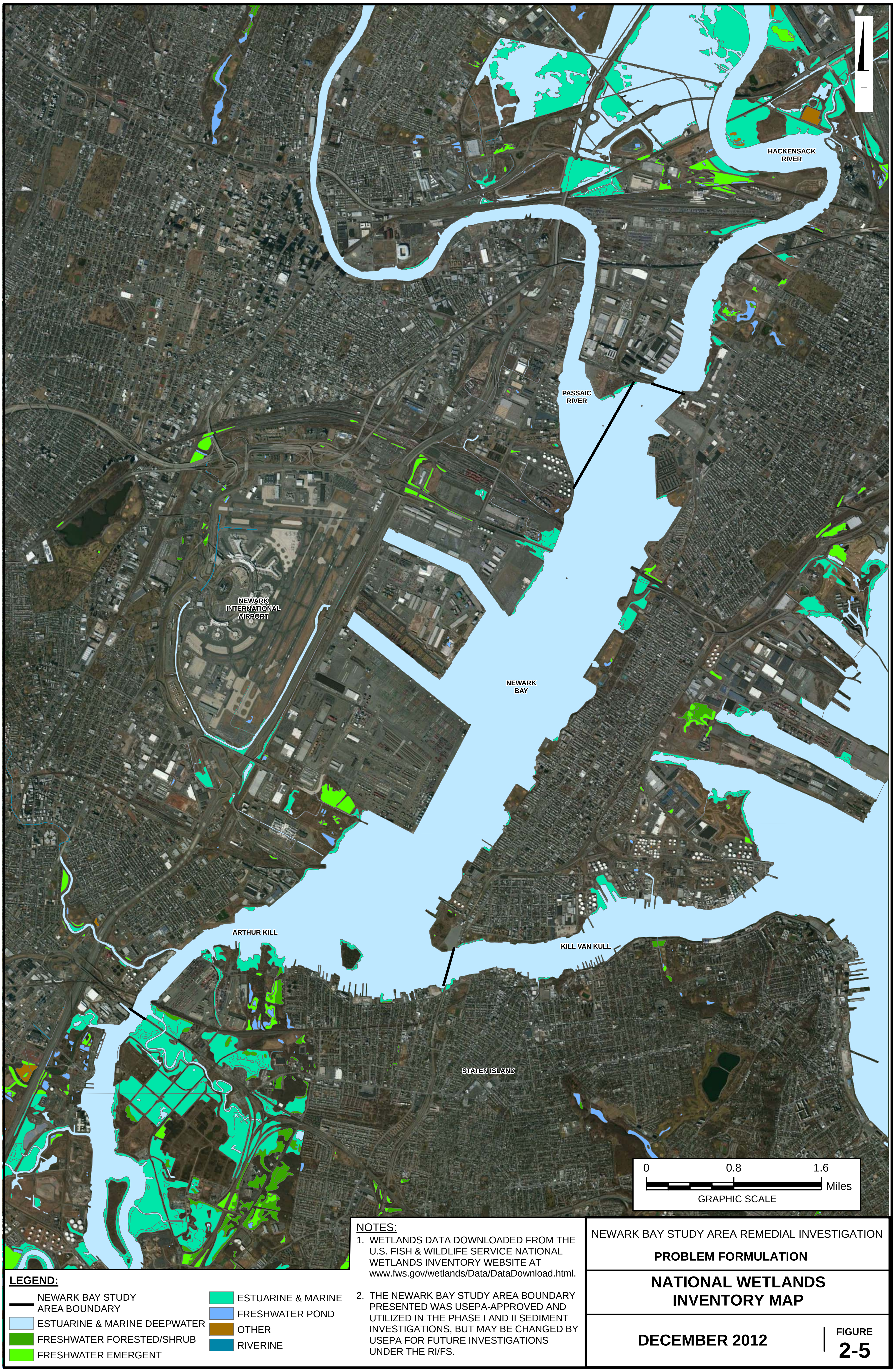
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

PROBLEM FORMULATION

GEOMORPHIC AREAS

DECEMBER 2012

FIGURE **2-4**



NOTES:

1. WETLANDS DATA DOWNLOADED FROM THE U.S. FISH & WILDLIFE SERVICE NATIONAL WETLANDS INVENTORY WEBSITE AT www.fws.gov/wetlands/Data/DataDownload.html.
2. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

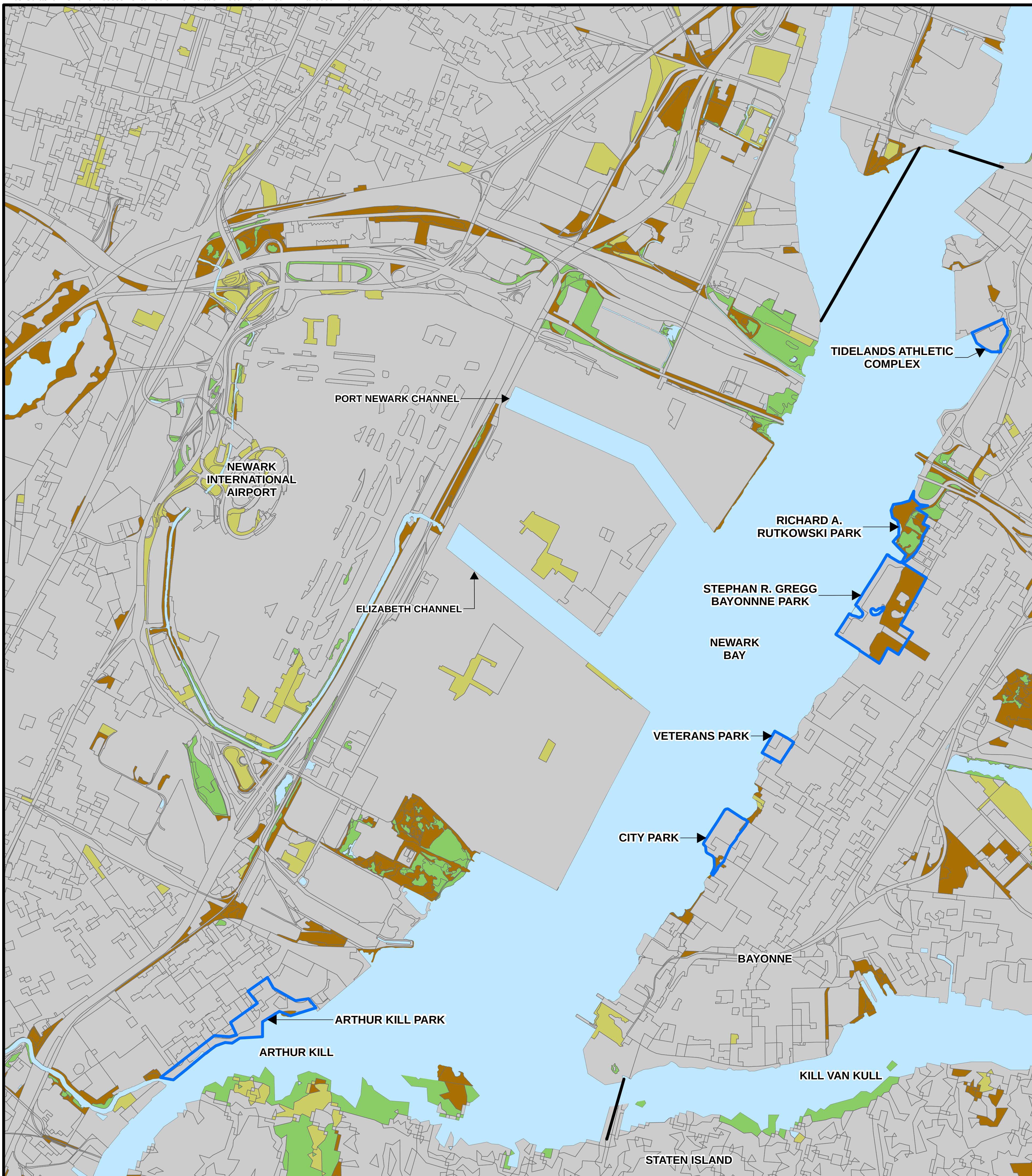
PROBLEM FORMULATION

NATIONAL WETLANDS INVENTORY MAP

DECEMBER 2012

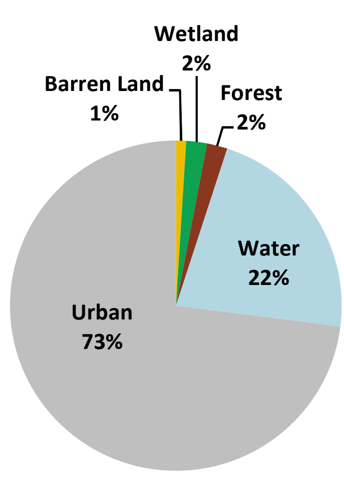
FIGURE 2-5

CITY: SYR DIV/GROUP: IT DB: KES LD: PIC: PM: TM: TR:
Newark Bay (B0009989.0005.00003)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\ERA Landuse.mxd 12/5/2012 4:40:42 PM



LEGEND:

- BARREN LAND
- FOREST
- URBAN
- WATER
- WETLANDS
- PARKS AND RECREATIONAL AREAS
- NEWARK BAY STUDY AREA BOUNDARY



Percentage of Land Cover

NOTES:

1. 2007 NEW JERSEY LAND USE DATA DOWNLOADED FROM THE NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION GEOGRAPHIC INFORMATION SYSTEM WEBSITE AT www.state.nj.us/dep/gis.
2. 2006 NEW YORK NATIONAL LAND COVER DATA DOWNLOADED FROM THE NEW YORK STATE GEOGRAPHIC INFORMATION SYSTEMS CLEARINGHOUSE AT www.nysgis.state.ny.us.
3. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

0 3,000 6,000 Feet
GRAPHIC SCALE

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

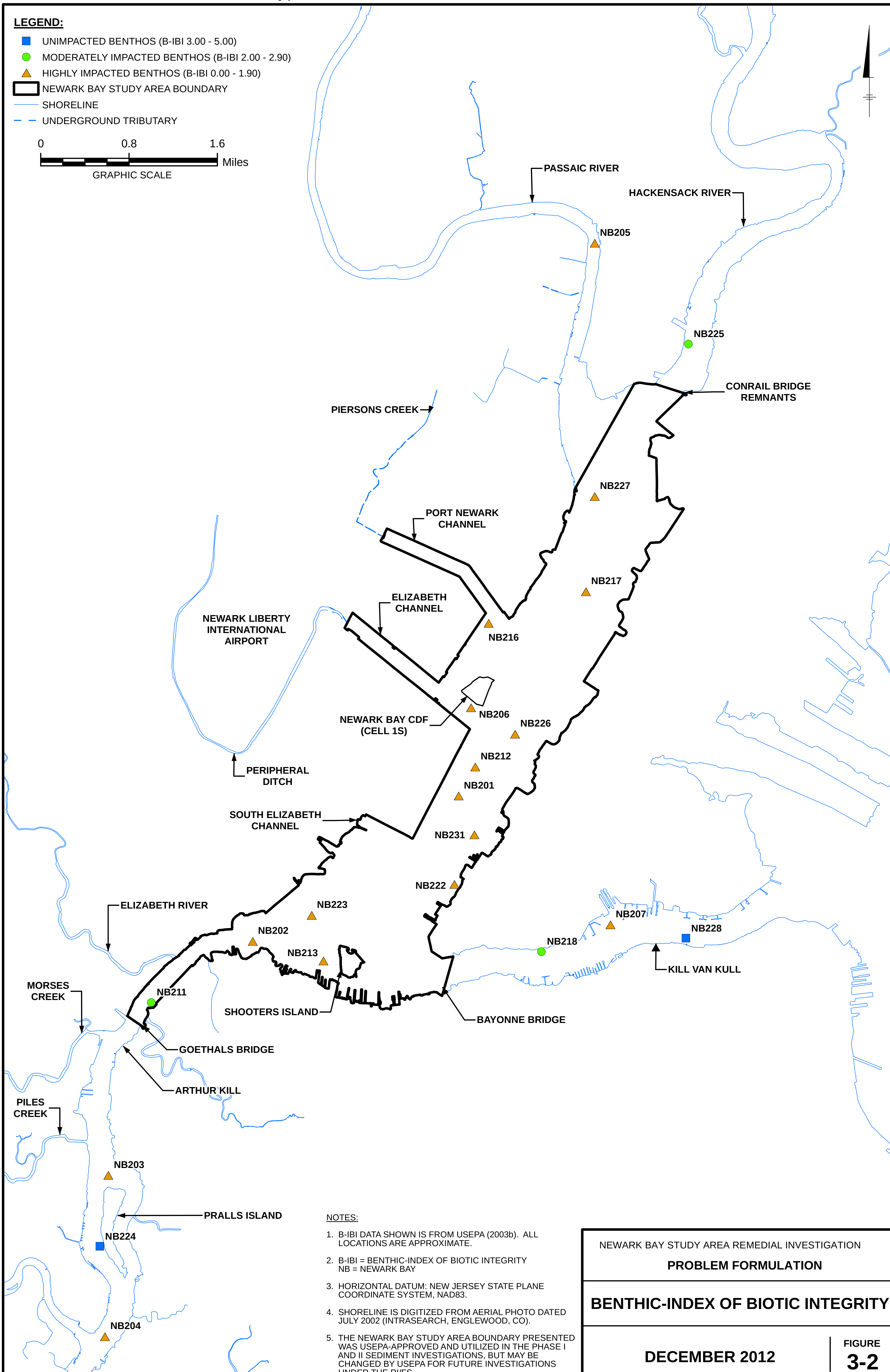
PROBLEM FORMULATION

LAND USE/ECOLOGICAL HABITATS

DECEMBER 2012

FIGURE 3-1

CITY: SYR DIV/GROUP: IM DB: K. SINSABAUGH PM:
Newark Bay (B0009989.001.00001)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\Biotic Integrity.mxd 12/5/2012 1:42:51 PM



NOTES:

1. B-IBI DATA SHOWN IS FROM USEPA (2003b). ALL LOCATIONS ARE APPROXIMATE.
2. B-IBI = BENTHIC-INDEX OF BIOTIC INTEGRITY
   NB = NEWARK BAY
3. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
4. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
5. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

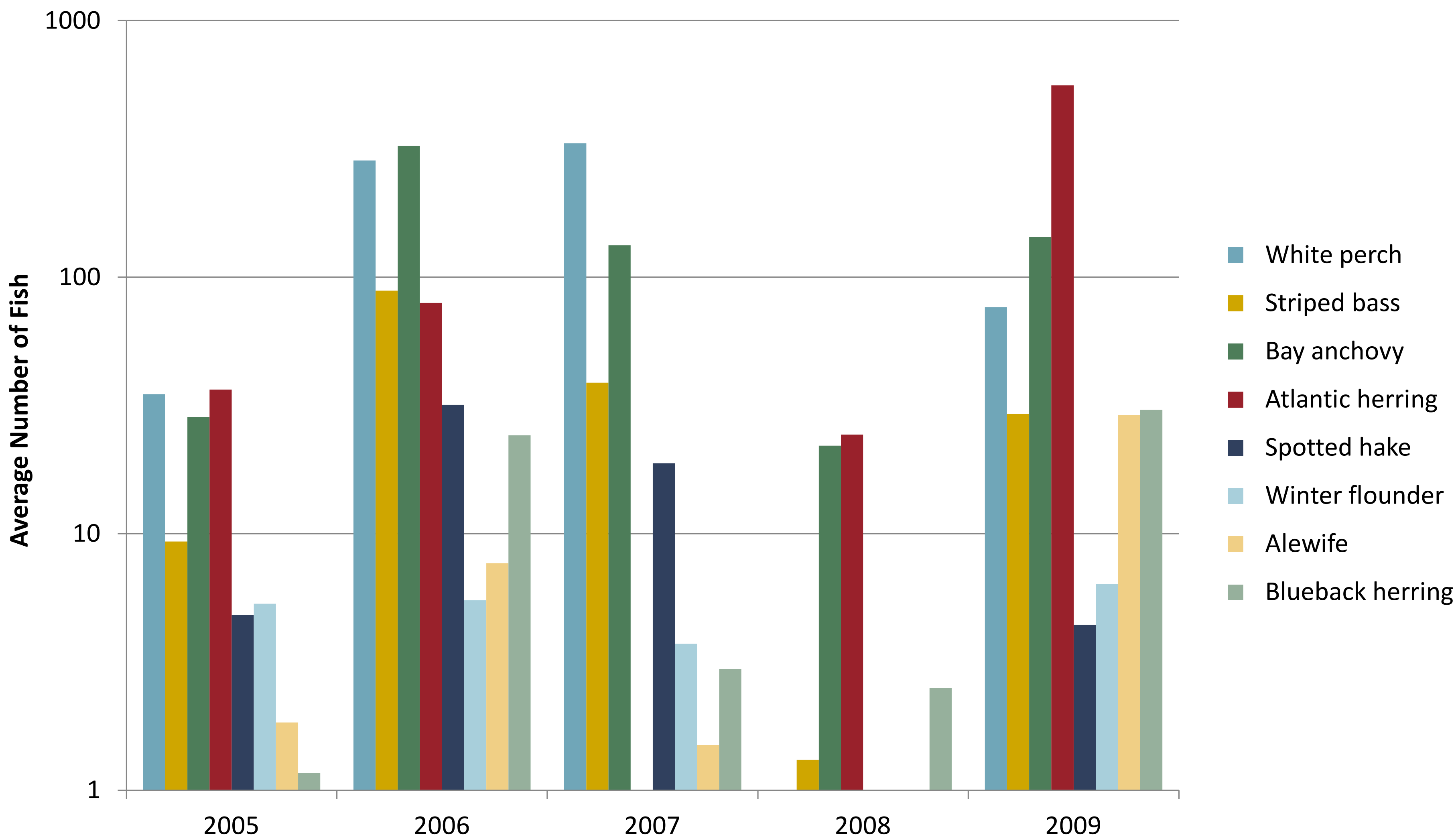
PROBLEM FORMULATION

BENTHIC-INDEX OF BIOTIC INTEGRITY

DECEMBER 2012

FIGURE
3-2

11/06/2012 SYRACUSE, NY-ENV/CAD DJHOWES
B0009989/0017/00002/CDR/09989G01.CDR



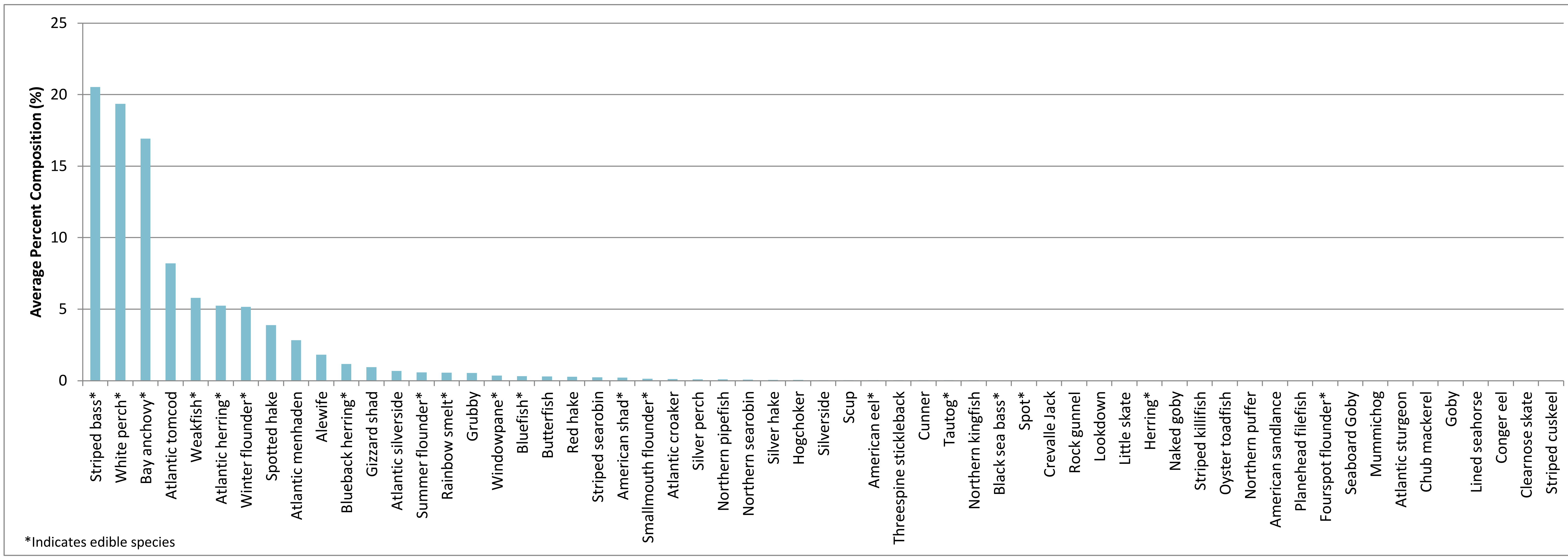
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

AVERAGE ANNUAL FINFISH CATCH IN NEWARK BAY (USACE 2005-2009)

DECEMBER 2012

FIGURE **3-3**

Notes:
From USACE (2005-2009).
Data are log-transformed.



Note:
From USACE (2004-2009), NOAA (1994), LMS (1996).

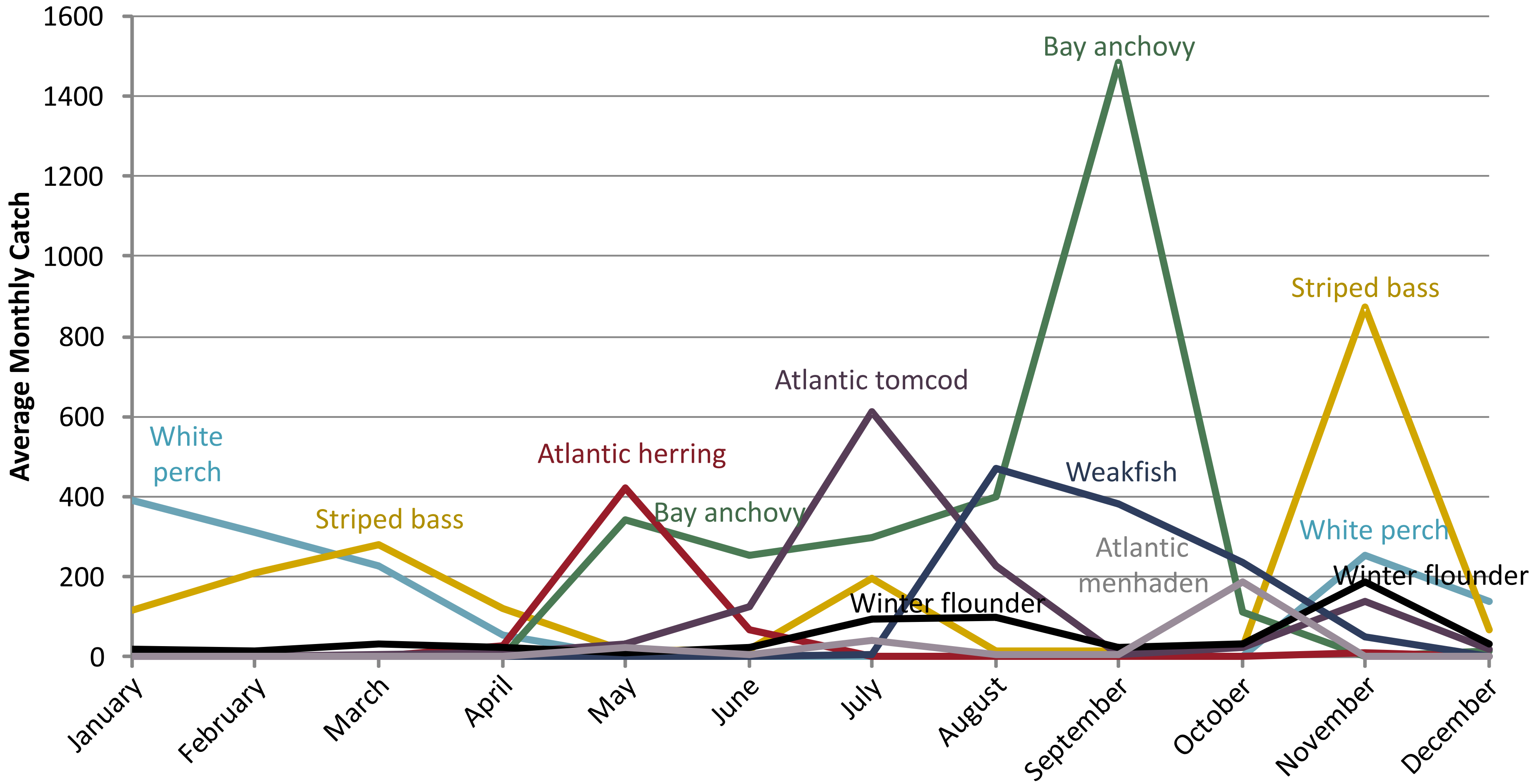
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

AVERAGE PERCENT COMPOSITION OF FINFISH CATCH IN NEWARK BAY (1993-2009)

DECEMBER 2012

FIGURE
3-4

12/04/2012 SYRACUSE, NY-ENV/CAD DJHOWES
B0009989/0017/00002/CDR/09989G03.CDR



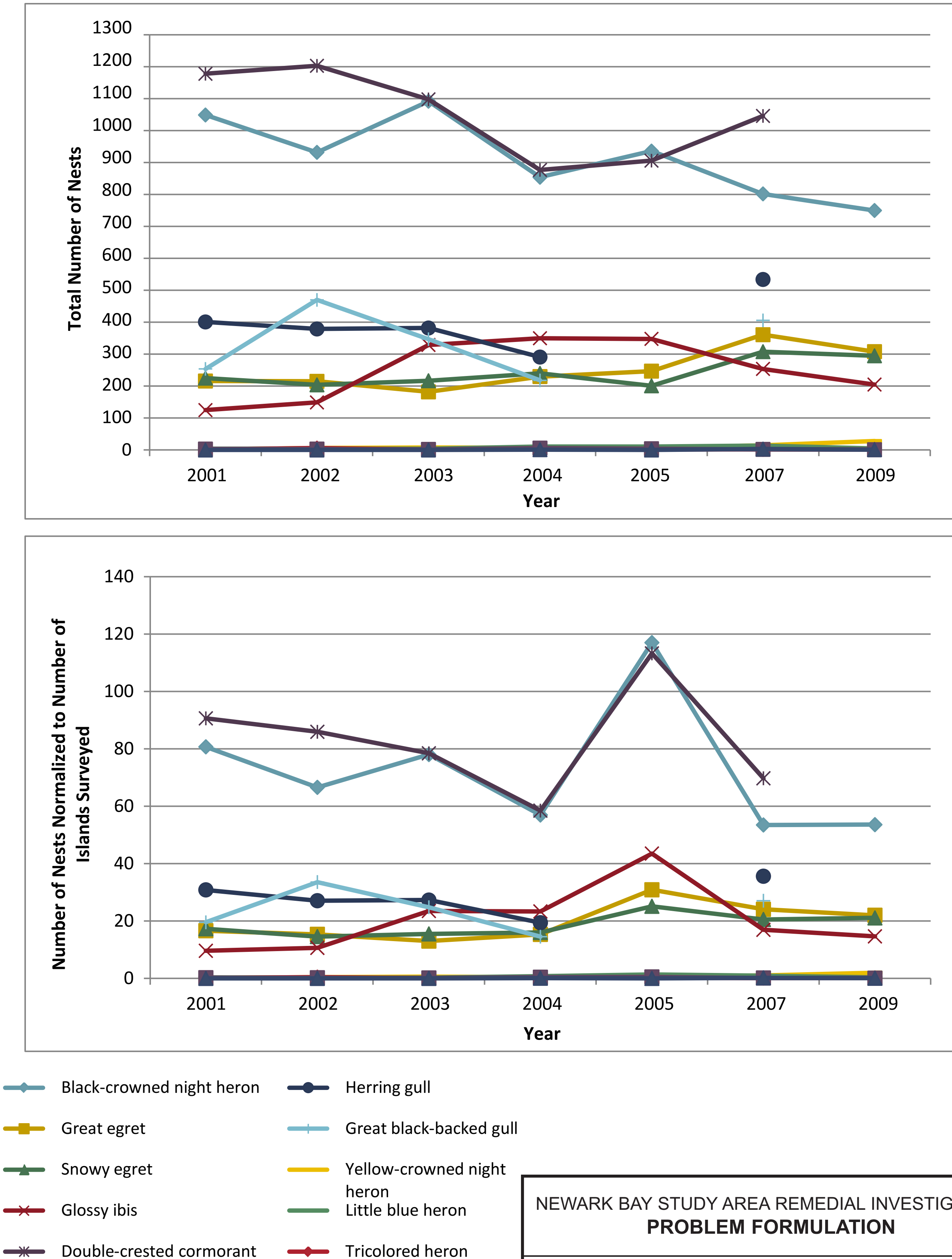
Note:
From USACE (2004-2009), NOAA (1994), LMS (1996).

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

AVERAGE MONTHLY COMPOSITION OF FINFISH CATCH IN NEWARK BAY (1993-2009)

DECEMBER 2012

FIGURE
3-5



Note:
From Harbor Herons Survey Data:
Bernick (2007), Bernick and Craig (2008),
Gelb (2004), and Harbor Herons Subcommittee (2010).

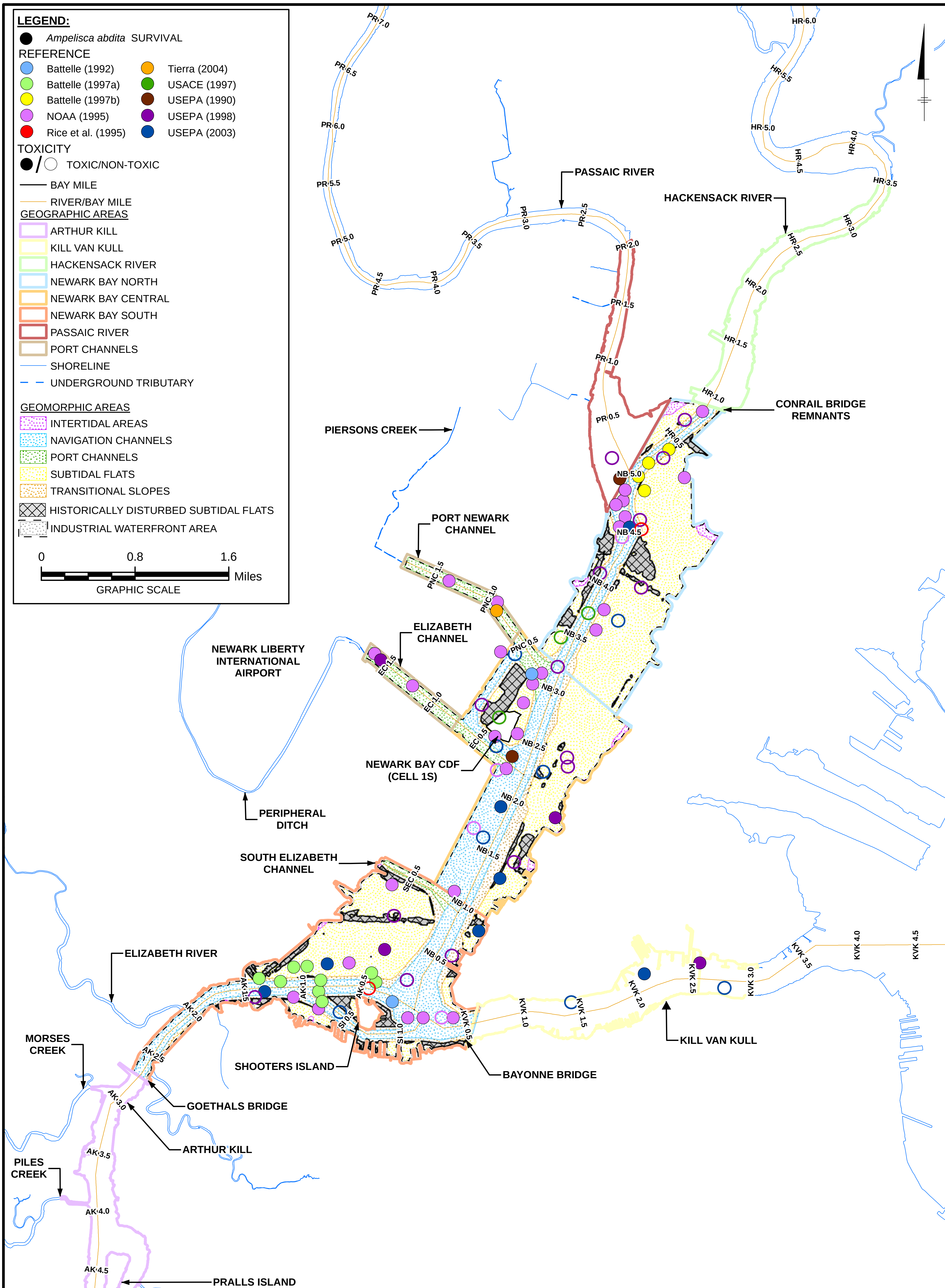
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

HARBOR HERONS PROJECT DATA (2001-2009)

DECEMBER 2012

FIGURE
3-6

City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: bdeclercq
Newark Bay (B0009989.0017.00005)
W:\GIS\Task\NBSA\RiskAssessment\ProblemFormulationDocument\mxd\Ampelisca Abdita Results.mxd 12/7/2012 9:48:12 AM



NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.
4. ALL LOCATIONS ARE APPROXIMATE.
5. TOXIC = ALL REPLICATE VALUES WITH LESS THAN 80% OF AVERAGE SURVIVAL/GROWTH OF CONTROLS.
6. NON-TOXIC = ALL REPLICATE VALUES WITH SURVIVAL/GROWTH GREATER THAN OR EQUAL TO 80% OF AVERAGE CONTROL SURVIVAL/GROWTH.
7. RIVER/BAY MILES CREATED BY DIVIDING RIVER CENTERLINE PROVIDED BY USEPA INTO 0.01-MILE SEGMENTS. HALF-MILE INCREMENTS ARE DISPLAYED ON THIS FIGURE.
8. HISTORICALLY DISTURBED SUBTIDAL FLAT AREAS BASED ON THE USACE GEOMORPHOLOGICAL REPORT DATED DECEMBER 31, 2006.
9. ABBREVIATIONS ARE AS FOLLOWS:
   AK = ARTHUR KILL
   EC = ELIZABETH CHANNEL
   HR = HACKENSACK RIVER
   KVK = KILL VAN KULL
   NB = NEWARK BAY
   PNC = PORT NEWARK CHANNEL
   PR = PASSAIC RIVER
   SEC = SOUTH ELIZABETH CHANNEL
   SI = SHOOTERS ISLAND

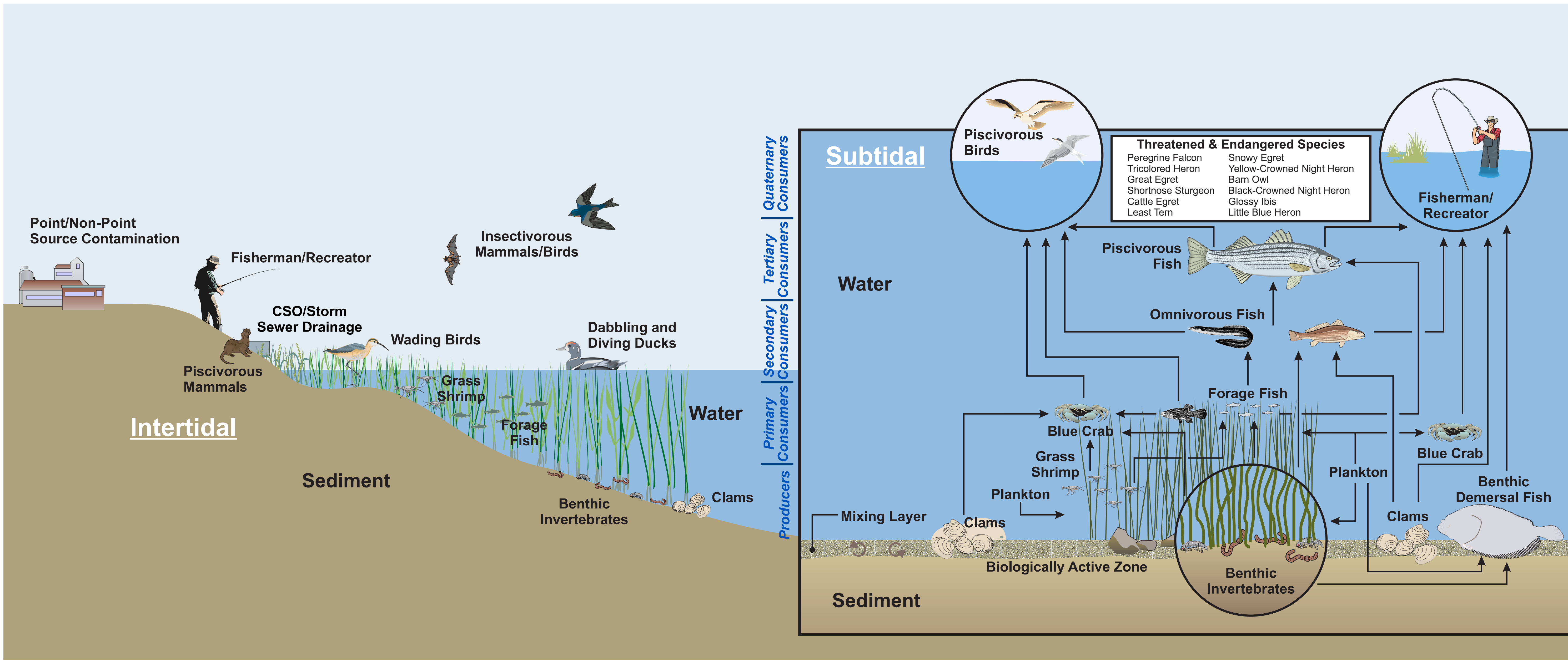
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

PROBLEM FORMULATION

HISTORICAL *AMPELISCA ABDITA* TOXICITY RESULTS

DECEMBER 2012

FIGURE **3-7**



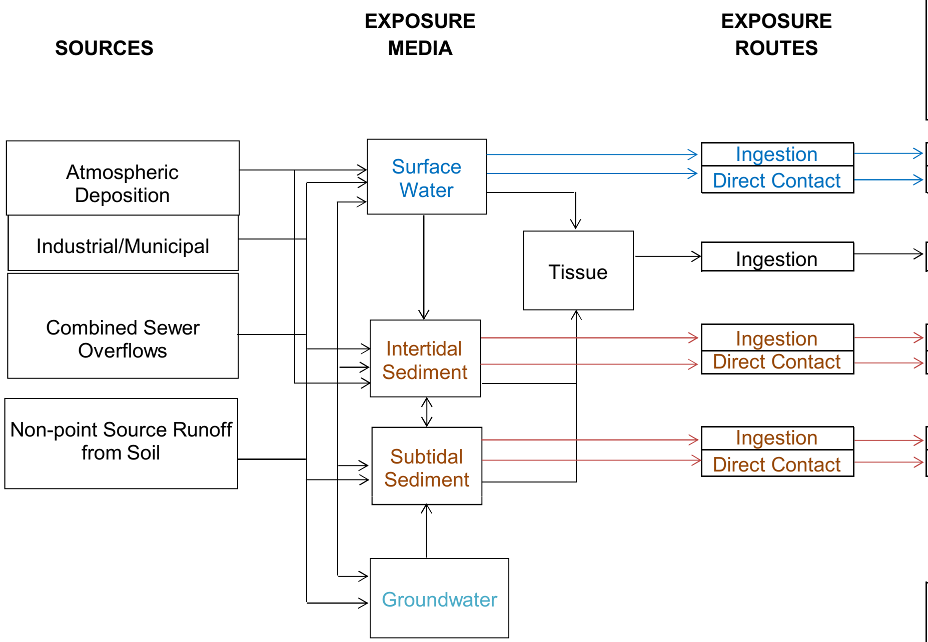
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

FOOD WEB DIAGRAM

DECEMBER 2012

FIGURE
4-1

07/16/2012 SYRACUSE, NY-ENV/CAD DJHOWES
B0009989/0011/00001/CDR/09989G01.CDR



Ecological Receptors

Exposure Media	Exposure Route	Aquatic Plants	Plankton	Benthic Invertebrate Community	Crustaceans	Mollusks	Forage Fish	Benthic Fish	Pelagic Fish	Herbivorous and Omnivorous Birds	Benthic-Feeding Birds	Insectivorous Birds and Mammals	Piscivorous Birds and Mammals
Surface Water	Ingestion	NA	X	X	X	X	X	X	X	X	X	X	X
Surface Water	Direct Contact	X	X	X	X	X	X	X	X	O	O	O	O
Tissue	Ingestion	NA	NA	NA	O	NA	O	O	O	X	X	X	X
Intertidal Sediment	Ingestion	NA	NA	X	X	X	X	O	O	X	X	O	X
Intertidal Sediment	Direct Contact	X	NA	X	X	X	X	O	O	O	O	O	O
Subtidal Sediment	Ingestion	NA	NA	X	X	X	X	X	O	O	O	O	O
Subtidal Sediment	Direct Contact	O	NA	X	X	X	X	X	O	O	O	O	O

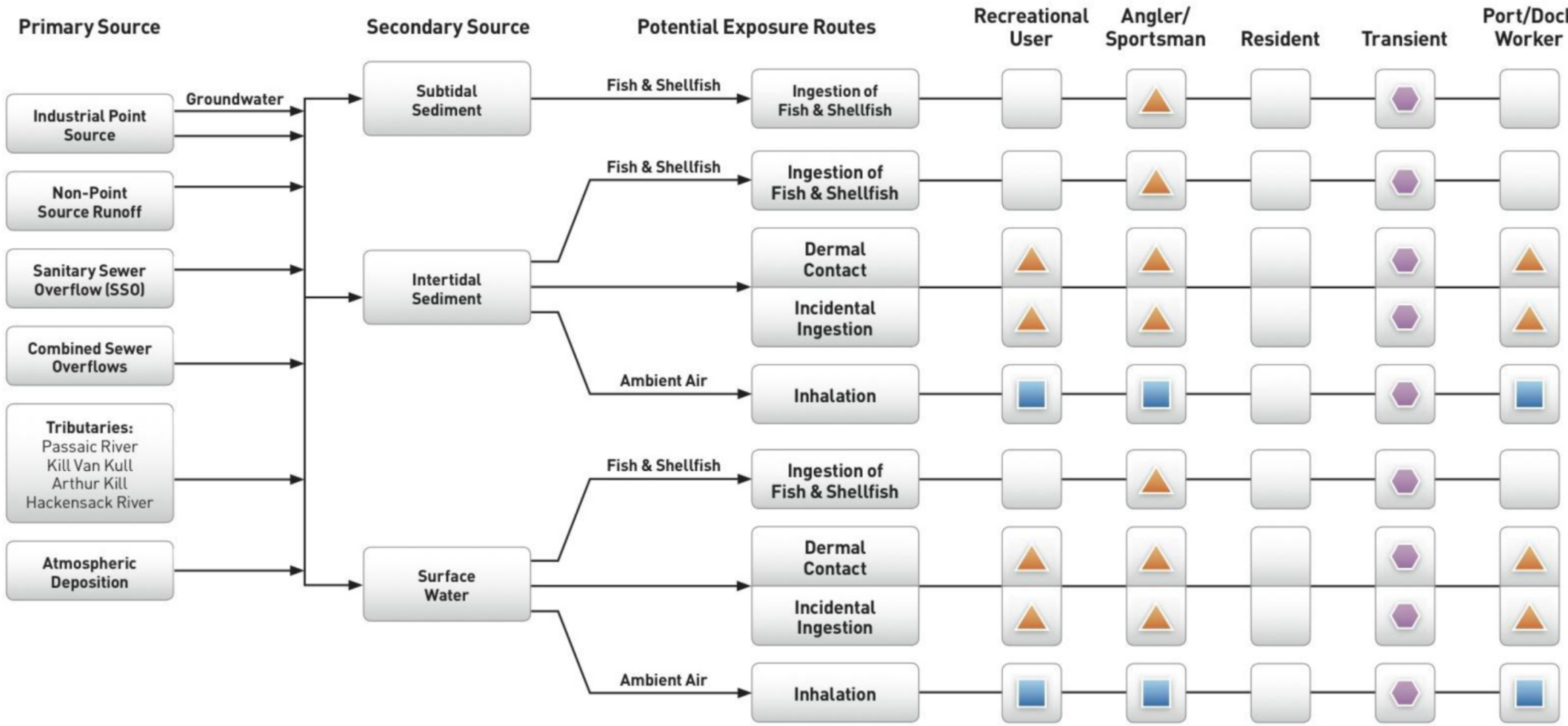
Legend
NA Pathway not applicable.
X Major, Complete Exposure Pathway
O Minor, Potentially Complete Exposure Pathway

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

ECOLOGICAL EXPOSURE PATHWAYS

DECEMBER 2012

FIGURE
4-2



NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
PROBLEM FORMULATION

CONCEPTUAL SITE MODEL: HUMAN HEALTH

DECEMBER 2012

FIGURE
5-1

Appendix A

Natural Heritage Database Request Results

State of New Jersey

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Parks and Forestry
Mail Code 501-04
ONLM -Natural Heritage Program
P.O. Box 420
Trenton, NJ 08625-0420
Tel. #609-984-1339
Fax. #609-984-1427

BOB MARTIN
Commissioner

April 18, 2012

Melissa Beauchemin
ARCADIS
194 Forbes Road
Braintree, MA 02184

Re: Newark Bay Ecological Risk Assessment

Dear Ms. Beauchemin:

Thank you for your data request regarding rare species information for the above referenced project site in Newark, Elizabeth and Bayonne Cities, Essex, Union and Hudson County.

Searches of the Natural Heritage Database and the Landscape Project (Version 3.1) are based on a representation of the boundaries of your project site in our Geographic Information System (GIS). We make every effort to accurately transfer your project bounds from the topographic map(s) submitted with the Request for Data into our Geographic Information System. We do not typically verify that your project bounds are accurate, or check them against other sources.

We have checked the Landscape Project habitat mapping and the Biotics Database for occurrences of any rare wildlife species or wildlife habitat on the referenced site. The Natural Heritage Database was searched for occurrences of rare plant species or ecological communities that may be on the project site. Please refer to Table 1 (attached) to determine if any rare plant species, ecological communities, or rare wildlife species or wildlife habitat are documented on site. A detailed report is provided for each category coded as 'Yes' in Table 1.

We have also checked the Landscape Project habitat mapping and Biotics Database for occurrences of rare wildlife species or wildlife habitat in the immediate vicinity (within ¼ mile) of the referenced site. Additionally, the Natural Heritage Database was checked for occurrences of rare plant species or ecological communities within ¼ mile of the site. Please refer to Table 2 (attached) to determine if any rare plant species, ecological communities, or rare wildlife species or wildlife habitat are documented within the immediate vicinity of the site. Detailed reports are provided for all categories coded as 'Yes' in Table 2. These reports may include species that have also been documented on the project site.

The Natural Heritage Program reviews its data periodically to identify priority sites for natural diversity in the State. Included as priority sites are some of the State's best habitats for rare and endangered species and ecological communities. Please refer to Tables 1 and 2 (attached) to determine if any priority sites are located on or in the vicinity of the site.

A list of rare plant species and ecological communities that have been documented from Essex, Union and Hudson County can be downloaded from http://www.state.nj.us/dep/parksandforests/natural/heritage/countylist.html. If suitable habitat is present at the project site, the species in that list have potential to be present.

Status and rank codes used in the tables and lists are defined in EXPLANATION OF CODES USED IN NATURAL HERITAGE REPORTS, which can be downloaded from http://www.state.nj.us/dep/parksandforests/natural/heritage/nhpcodes_2010.pdf.

If you have questions concerning the wildlife records or wildlife species mentioned in this response, we recommend that you visit the interactive NJ-GeoWeb website at the following URL, http://www.state.nj.us/dep/gis/geowebsplash.htm or contact the Division of Fish and Wildlife, Endangered and Nongame Species Program at (609) 292-9400.

PLEASE SEE 'CAUTIONS AND RESTRICTIONS ON NHP DATA', which can be downloaded from http://www.state.nj.us/dep/parksandforests/natural/heritage/newcaution2008.pdf.

Thank you for consulting the Natural Heritage Program. The attached invoice details the payment due for processing this data request. Feel free to contact us again regarding any future data requests.

Sincerely,

Robert J. Cartica
Administrator

c: NHP File No. 12-4007462-1182

Table 1: On Site Data Request Search Results (7 Possible Reports)

Rare Plants/Ecological Communities Possibly On Site:	No
Rare Plants/Ecological Communities On Site/Immediate Vicinity:	No
Natural Heritage Priority Sites On Site:	No
Landscape 3.1 Species Based Patches On Site:	Yes
Landscape 3.1 Vernal Pool Habitat On Site:	No
Landscape 3.1 Stream/Mussel Habitat On Site:	No
Other Animals Tracked by ENSP On Site:	No

Rare Wildlife Species or Wildlife Habitat on the Project Site Based on Search of Landscape Project 3.1 Species Based Patches

Class	Common Name	Scientific Name	Feature Type	Rank	Federal Protection	State Protection	Grank	Srank
Aves								
	Black-crowned Night-heron	Nycticorax nycticorax	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Cattle Egret	Bubulcus ibis	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Glossy Ibis	Plegadis falcinellus	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Least Tern	Sternula antillarum	Foraging	4	NA	State Endangered	G4	S1B,S1N
	Little Blue Heron	Egretta caerulea	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Osprey	Pandion haliaetus	Foraging	3	NA	State Threatened	G5	S2B
	Peregrine Falcon	Falco peregrinus	Urban Nest	4	NA	State Endangered	G4	S1B,S3N
	Snowy Egret	Egretta thula	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Tricolored Heron	Egretta tricolor	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Yellow-crowned Night-heron	Nyctanassa violacea	Foraging	3	NA	State Threatened	G5	S2B,S2N
Insecta								
	Checkered White	Pontia protodice	Breeding/Courtship	3	NA	State Threatened	G4	S2
Osteichthyes								
	Shortnose Sturgeon	Acipenser brevirostrum	Migration Corridor - Adult Sighting	5	Federally Listed Endangered	State Endangered	G3	S1

Table 2: Vicinity Data Request Search Results (6 possible reports)

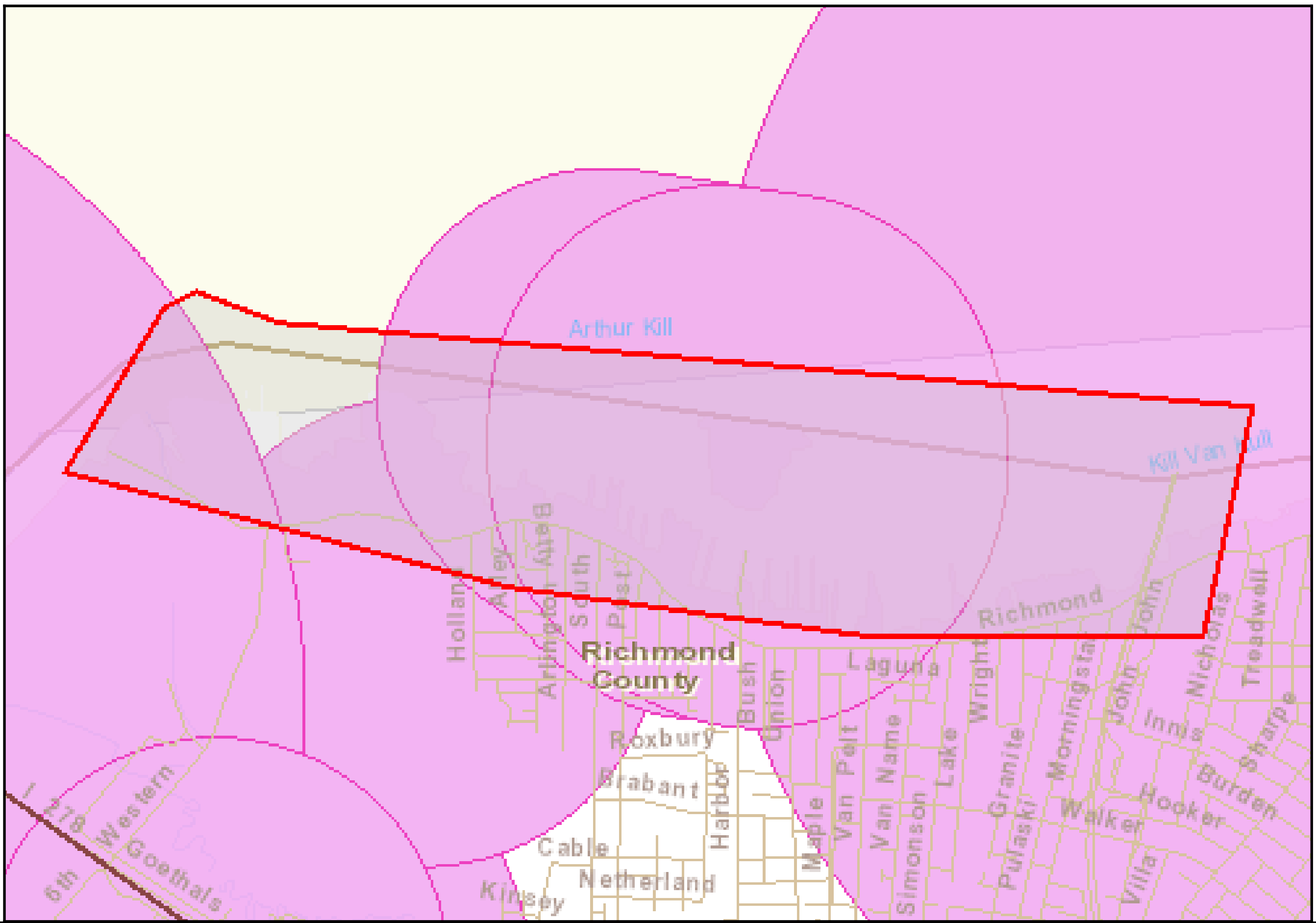
Rare Plants/Ecological Communities within the Vicinity:	No
Natural Heritage Priority Sites within the Vicinity:	No
Landscape 3.1 Species Based Patches within the Vicinity:	Yes
Landscape 3.1 Vernal Pool Habitat within the Vicinity:	No
Landscape 3.1 Stream/Mussel Habitat within the Vicnity:	No
Other Animals Tracked by ENSP within the Vicnity:	No

Rare Wildlife Species or Wildlife Habitat Within the Immediate Vicinity of the Project Site Based on Search of Landscape Project 3.1 Species Based Patches

Class	Common Name	Scientific Name	Feature Type	Rank	Federal Protection	State Protection	Grank	Srank
Aves								
	Black-crowned Night-heron	Nycticorax nycticorax	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Cattle Egret	Bubulcus ibis	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Glossy Ibis	Plegadis falcinellus	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Least Tern	Sternula antillarum	Foraging	4	NA	State Endangered	G4	S1B,S1N
	Little Blue Heron	Egretta caerulea	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Osprey	Pandion haliaetus	Foraging	3	NA	State Threatened	G5	S2B
	Peregrine Falcon	Falco peregrinus	Urban Nest	4	NA	State Endangered	G4	S1B,S3N
	Snowy Egret	Egretta thula	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Tricolored Heron	Egretta tricolor	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Upland Sandpiper	Bartramia longicauda	Breeding Sighting	4	NA	State Endangered	G5	S1B,S1N
	Yellow-crowned Night-heron	Nyctanassa violacea	Foraging	3	NA	State Threatened	G5	S2B,S2N
Insecta								
	Checkered White	Pontia protodice	Breeding/Courtship	3	NA	State Threatened	G4	S2
Osteicht								
	Shortnose Sturgeon	Acipenser brevirostrum	Migration Corridor - Adult Sighting	5	Federally Listed Endangered	State Endangered	G3	S1

New York Nature Explorer
User Defined Results Report

Criteria: Selected Map Area



Common Name	Subgroup	Distribution Status	Year Last Documented	Protection Status		Conservation Rank	
				State	Federal	State	Global

Animal: Birds

Barn Owl *Tyto alba*	Owls	Recently Confirmed	2002	Protected Bird		S1S2	G5
Cattle Egret *Bubulcus ibis*	Herons, Bitterns, Egrets, Ibises	Recently Confirmed	2004	Protected Bird		S2	G5
Glossy Ibis *Plegadis falcinellus*	Herons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2	G5
Great Egret *Ardea alba*	Herons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2	G5
Little Blue Heron *Egretta caerulea*	Herons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2	G5

New York Nature Explorer

Common Name	Subgroup	Distribution Status	Year Last Documented	Protection Status		Conservation Rank	
				State	Federal	State	Global
Snowy Egret *Egretta thula*	Herons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2S3	G5
Yellow-crowned Night-Heron *Nyctanassa violacea*	Herons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2	G5

Animal: Dragonflies and Damselflies

Mocha Emerald *Somatochlora linearis*	Dragonflies	Historically Confirmed	1926			S2S3	G5
Rambur's Forktail *Ischnura ramburii*	Damselflies	Historically Confirmed	1913			S2	G5

Animal: Animal Assemblages

Colonial Waterbird Nesting Area *Colonial Waterbird Nesting Area*	Animal Assemblages	Recently Confirmed	1998			S3	GNR
Gull Colony *Gull Colony*	Animal Assemblages	Recently Confirmed	1995			SNR	GNR

Plant: Flowering Plants

Angled Spikerush *Eleocharis quadrangulata*	Sedges	Recently Confirmed	1998	Endangered		S1	G4

Note: Restricted plants and animals may also have also been documented in one or more of the Towns or Cities in which your user-defined area is located, but are not listed in these results. This application does not provide information at the level of Town or City on state-listed animals and on other sensitive animals and plants. A list of the restricted animals and plants documented at the corresponding county level can be obtained via the County link(s) on the original User Defined Search Results page. Any individual plant or animal on this county's restricted list may or may not occur in this particular user-defined area.

This list only includes records of rare species and significant natural communities from the databases of the NY Natural Heritage Program. This list is not a definitive statement about the presence or absence of all plants and animals, including rare or state-listed species, or of all significant natural communities. For most areas, comprehensive field surveys have not been conducted, and this list should not be considered a substitute for on-site surveys.

Appendix B

Current and Future Land Use and
Access to the Shoreline

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Appendix B

Current and Future Land Use
and Access to the Shoreline

1. Current Land Use and Access to the Shoreline

All land with boundaries comprising the shoreline of the Newark Bay Study Area (NBSA) was evaluated for the potential for humans to contact sediments. Reconnaissance was carried out using a series of approaches to assess every tenth of a mile of the shoreline. First, area zoning maps from Kearny, Jersey City, Bayonne, New York City, Elizabeth, and Newark were studied to determine the current designated land use of all bounding properties (City of Bayonne 2001; City of Elizabeth 2012; City of Newark 2004; Jersey City 2001; Kearny Zoning 2009; New York City 2011a). Second, Google Earth (imagery date: June 17, 2010) was used to determine whether the shoreline and sediments could be easily accessed. For areas in which this determination was not clear from Google Earth imagery, on-site reconnaissance was conducted (Appendix C).

Categories of shoreline accessibility were generally based first on whether the land was zoned industrial (associated with limited accessibility) or non-industrial (greater potential for accessibility), then further classified by the type of access as follows (representative photographs of each category identified on the NBSA are presented as Figures B1 through B4):

- ***Industrial/Manufacturing – No Access –*** An area of shoreline zoned for industrial or manufacturing purposes and has no readily available access to sediment by humans (Figure B1).

- ***Industrial/Manufacturing – With Access –*** An area of shoreline zoned for industrial or manufacturing purposes that presents access to the sediment by humans (Figure B2).

- ***Non-Industrial - No Access –*** A non-industrial zoned area of shoreline that does not present access to sediment due to physical boundaries such as fences and steep slopes (Figure B3).

- ***Non-Industrial – With Recreational Access –*** A non-industrial zoned area of shoreline that presents the possibility of recreational access to sediment. The public could access NBSA sediment and surface water for activities such as wading, swimming, boating, canoeing, and fishing or crabbing (Figure B4).

- ***Non-Industrial – With Residential Access –*** A non-industrial zoned area of shoreline that presents the possibility of residential access to sediment, with residential access defined as exposure 350 days/year for 30 years.

Additionally, segment lengths for each category were measured using Google Earth from an altitude of 200 meters.

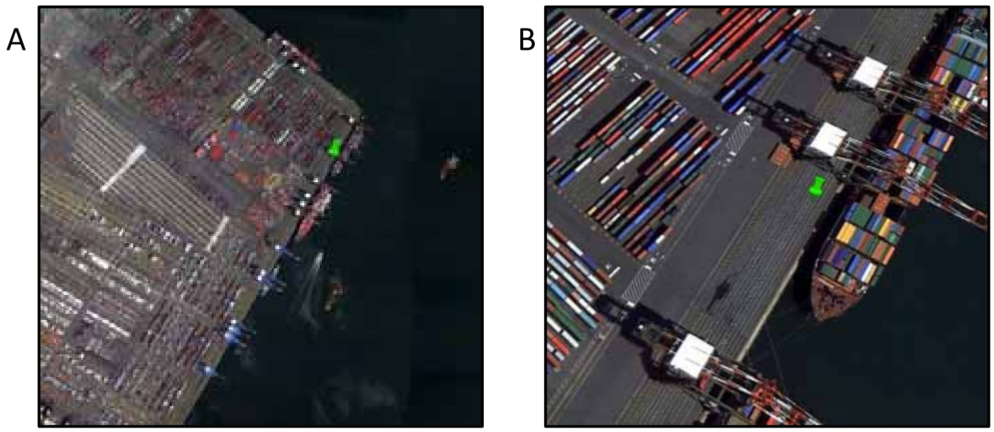


Figure B1 Industrial/Manufacturing – No Access
Representative photos: A) Aerial view. B) Zoomed view.

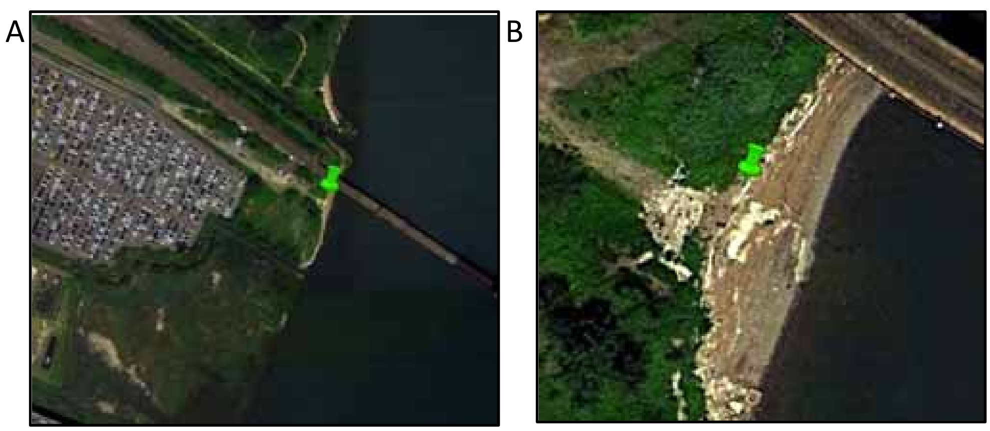


Figure B2 Industrial/Manufacturing – With Access
Representative photos: A) Aerial view. B) Zoomed view.

Based on the findings from this series of evaluations, zoning (land use) and shoreline accessibility were characterized, summarized in Tables B1 and B2, and graphically demonstrated in Figures B5 and B6. The majority of property around the NBSA was zoned as industrial (74%) – most of which (70%) was determined to have “no access.” For the non-industrial property, only 14% of the total perimeter of the NBSA was found to have access consistent with recreational exposures. Notably, no properties or shoreline land segments were identified that would be characteristic of a standard residential exposure scenario (e.g., exposure to sediments 350 days/year). Specifically, there were no areas of residentially zoned land in which there was readily available access to the shoreline, nor was there evidence (e.g., picnic tables along the shoreline, walkways/stairs indicating use of the shoreline area) of a scenario in which residents were interacting with the shoreline in a manner equivalent to the residential exposure scenario. Most residentially zoned properties had fences, obstructions, or significant land elevation differences inhibiting direct contact with NBSA surface water and sediment (Figure B3-D).

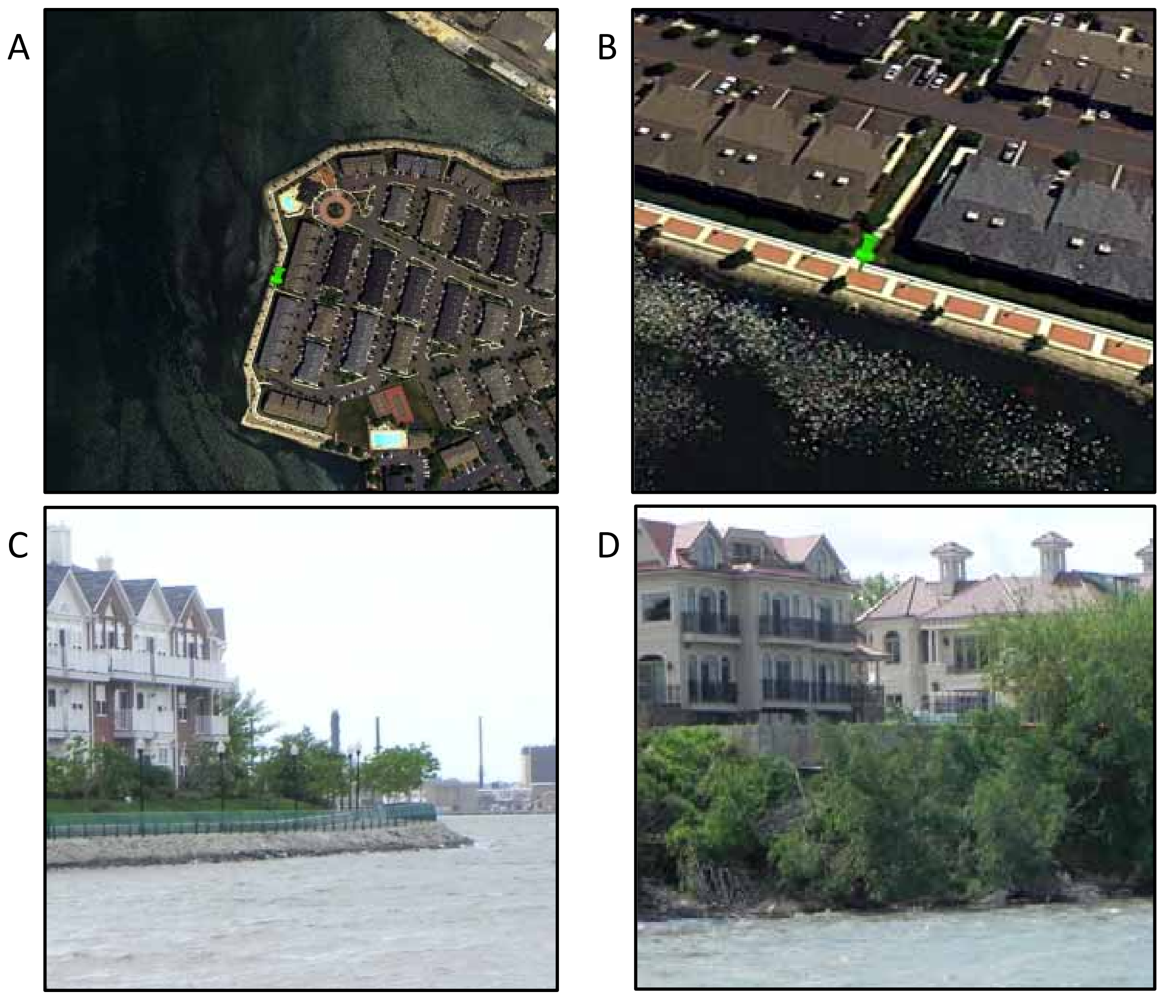


Figure B3 Non-Industrial – No Access
Representative photos: A) Aerial view. B) Zoomed view. C) 2012 photograph of walkway with no access. D) 2012 photograph of residential zoned property with steep slope and no access

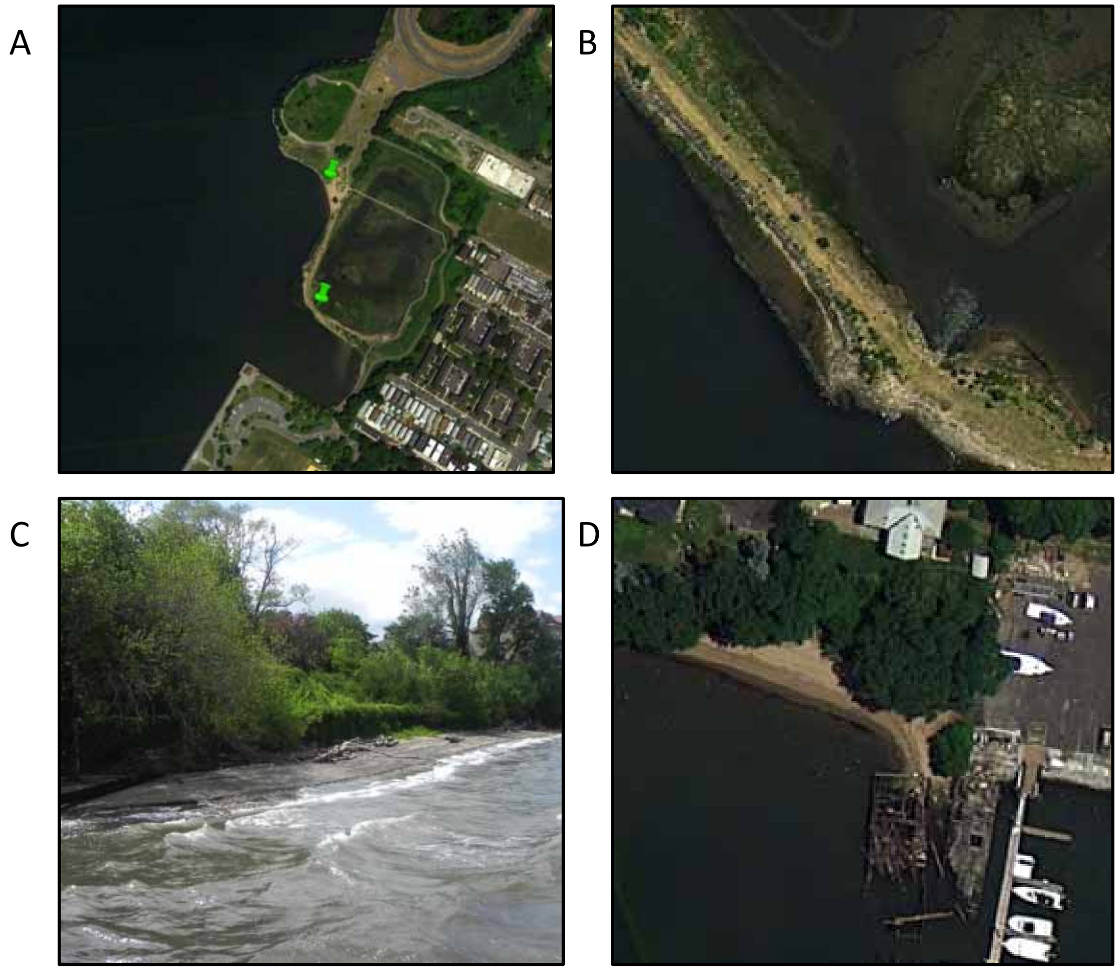


Figure B4 Non-Industrial – With Recreational Access
Representative photos: A) Aerial view. B) Zoomed view. C) Beach area. D) Boating docks.

Appendix B

Current and Future Land Use
and Access to the Shoreline

Table B1 NBSA Shoreline Segment Information – Current Land Use

No.	Location	Description	Length (mile[s])	Zoning Category	Shoreline Access Characterization
1	Kearny, NJ	Kearny Point	0.4	Industrial	Industrial/Manufacturing – With Access
2	Jersey City, NJ	Kellogg St	0.2	Redevelopment Area	Industrial/Manufacturing – No Access
3	Jersey City, NJ	Droyers Point (1)	0.1	Redevelopment Area	Non-Industrial – With Recreational Access
4	Jersey City, NJ	Droyers Point (2)	0.9	Redevelopment Area	Non-Industrial - No Access
5	Jersey City, NJ	The Thomas M. Gerrity Athletic Complex	0.2	Residential	Non-Industrial – With Recreational Access
6	Jersey City, NJ; Bayonne, NJ	Route 440	0.9	Community Commercial	Non-Industrial - No Access
7	Bayonne, NJ	Route 440, south of RR bridge	0.1	Community Commercial	Non-Industrial – With Recreational Access
8	Bayonne, NJ	Route 440 to Rutkowski Park	0.2	Community Commercial	Non-Industrial - No Access
9	Bayonne, NJ	Rutkowski Park	0.6	Residential	Non-Industrial – With Recreational Access
10	Bayonne, NJ	Bayonne Park	0.8	Residential	Non-Industrial - No Access
11	Bayonne, NJ	Park Dr. to Benmore Terr.	0.1	Residential	Non-Industrial – With Recreational Access
12	Bayonne, NJ	Benmore Terr. to W 31st St	0.4	Residential	Non-Industrial - No Access
13	Bayonne, NJ	W 31st St to W 30th St	0.1	Residential	Non-Industrial – With Recreational Access
14	Bayonne, NJ	Bayonne HS (North)	0.1	Residential	Non-Industrial - No Access
15	Bayonne, NJ	Bayonne HS to W 24th St	0.4	Residential	Non-Industrial – With Recreational Access
16	Bayonne, NJ	W 23rd St	0.1	Residential	Non-Industrial - No Access
17	Bayonne, NJ	W 22nd St	0.1	Residential	Non-Industrial – With Recreational Access
18	Bayonne, NJ	Between W 22nd and W 21st St	0.1	Residential	Non-Industrial - No Access
19	Bayonne, NJ	W 21st St to Marina	0.8	Residential	Non-Industrial – With Recreational Access
20	Bayonne, NJ	Marina to W 8th St	0.2	Residential	Non-Industrial - No Access
21	Bayonne, NJ	W 8th to Marina 2	0.2	Residential	Non-Industrial – With Recreational Access
22	Bayonne, NJ	South of Marina 2	0.1	Residential	Non-Industrial - No Access
23	Bayonne, NJ	Community commercial area	0.3	Community Commercial	Non-Industrial – With Recreational Access
24	Bayonne, NJ	Heavy Industrial area	0.4	Industrial	Industrial/Manufacturing – No Access

No.	Location	Description	Length (mile[s])	Zoning Category	Shoreline Access Characterization
25	Bayonne, NJ	Waterfront Dev District	0.8	Waterfront Development District	Industrial/Manufacturing – With Access
26	Staten Island, NY	Staten Island (small section by bridge)	0.1	Manufacturing	Industrial/Manufacturing – With Access
27	Staten Island, NY	Staten Island East	3.2	Manufacturing	Industrial/Manufacturing – No Access
28	Staten Island, NY	Staten Island West	1.6	Manufacturing	Industrial/Manufacturing – With Access
29	Staten Island, NY	Shooters Island	0.8	Manufacturing	Industrial/Manufacturing – With Access
30	Elizabeth, NJ	MRC	0.4	Manufacturing, Research, Commercial	Non-Industrial – With Recreational Access
31	Elizabeth, NJ	MRC 2	1.0	Manufacturing, Research, Commercial	Industrial/Manufacturing – No Access
32	Elizabeth, NJ	Kapkowski	1.1	Kapkowski Rd Redevelopment Area	Industrial/Manufacturing – With Access
33	Newark, NJ	Newark Port	8.4	Industrial	Industrial/Manufacturing – No Access
34	Newark, NJ	Area near HWY and RR bridges	0.9	Industrial	Industrial/Manufacturing – With Access
35	Newark, NJ	North of RR bridge	0.4	Industrial	Industrial/Manufacturing – No Access
36	Newark, NJ	North of HESS Plant	0.2	Industrial	Industrial/Manufacturing – With Access
37	Newark, NJ	Final NW Segment	0.6	Industrial	Industrial/Manufacturing – No Access

Table B2 NBSA Summary of Exposure Characterizations – Current Land Use

Characterization	Total Length (miles)	Percentage of Total Perimeter (%)
Industrial/Manufacturing – No Access	14.2	52
Industrial/Manufacturing – With Access	5.9	22
Non-Industrial – No Access	3.3	12
Non-Industrial – With Recreational Access	3.9	14
Non-Industrial – Residential Access	0	0
All Characterizations	27.3	100

2. Future Land Use and Access to the Shoreline

There are four areas (see Table B3 below and Figure B7) along the perimeter of the NBSA that have the potential to undergo future residential development. These areas were identified by regional zoning maps and further investigated by reviewing development plans from the respective cities or counties surrounding the NBSA to determine any potential differences between current and future land use with respect to potential exposures to sediments.

Table B3 NBSA Areas Slated for Alternative Future Development (Including Residential)

Zone	Length (mile[s])	Current Shoreline Access Characterization	Potential Future Use (and Shoreline Access Characterization)
Bayfront I Redevelopment Zone	0.2	Industrial/Manufacturing – No Access	Mixed-use residential, retail, parks or recreation, and commercial area (non-industrial area with no access)
Waterfront Development District	0.8	Industrial/Manufacturing – With Access	Mixed-use residential, parks, and commercial area (non-industrial area with recreational access)
Kapkowski Road Redevelopment Area	1.0	Industrial/Manufacturing – With Access	Mixed-use residential and commercial area (non-industrial area with recreational access)
Staten Island – North Shore	N/A	Industrial/Manufacturing – With Access	Currently planned for mixed-use recreational and commercial (non-industrial area with recreational access)

The Bayfront I Redevelopment Plan involves redeveloping the industrial area to a mixed-use community that will provide “access to an enhanced waterfront to the benefit of the entire Jersey City community.” (Jersey City 2008). Specifically, this area will include (when completed) new housing, retail, office space, parkland, and other amenities. Planning recommendations include a waterfront walkway (Jersey City 2008):

> “the riverfront walkway will be continued from the Droyers Point project along the Hackensack Riverfront to the adjacent property to the north.”

This plan would change the shoreline access characterization (above section) for the affected 0.2-mile stretch from an industrial area with no access to a non-industrial area with no access, given that the walkway will be continued (and the walkway is constructed so that it borders the shoreline but does not allow access). This change in categorization would not impact how exposure is assessed in the human health risk assessment (i.e., current and future plans involve recreational exposures).

The Waterfront Development District (also referred to as the Texaco Site) is currently zoned for a mix of residential and commercial uses, including one- and two-family dwellings, multi-family housing, retail, offices, restaurants, theaters, commercial recreation, and marinas. It is anticipated that the site will accommodate a mixed-use development with a significant portion earmarked for residential use. Notably, the area is currently being remediated due to contamination, though the plan states that it has the potential to be cleaned to residential site standards. According to the redevelopment plan (City of Bayonne 2000):

> “a remediation plan is being prepared for the remaining contaminated area adjacent to the Bayonne Bridge. The initial evaluation indicates that this small portion of the site may be unsuitable for residential use. This is a condition that should be factored into overall site development.”

The plan also states that the District should incorporate a waterfront walkway and that this walkway should conform to New Jersey Department of Environmental Protection (NJDEP) standards and has an inviting public access environment. There is also discussion regarding the existing pier as part of the recreational landscape, with the text stating that “the existing pier may be suitable for recreational use and/or a limited commercial use such as a restaurant.” This area is currently considered an industrial/manufacturing location where recreational access is possible, so the future plans would not change how exposure is characterized (i.e., recreational access under current and future scenarios).

The Kapkowski Road Redevelopment Area will be another mixed-use area, although limited information was available from the City of Elizabeth (Construction Journal 2012; Schoor DePalma, Inc. 2005) to specifically characterize future plans. The current shoreline access characterization of this 1-mile zone allows for possible recreational access. Because no information was available to suggest otherwise, it was assumed that residential and recreational plans would generally mimic other plans, which involve physical barriers to the waterfront such as walkway railings, fences, and other features (note: access could potentially change to an area with no NBSA access, depending on the final project plans). This area is currently considered an industrial/manufacturing location where recreational access is possible, so the future plans would not change how exposure is characterized (i.e., recreational access under current and future scenarios).

The North Shore of Staten Island is not currently zoned for redevelopment, but a task force, North Shore 2030, has been initiated as part of a comprehensive planning effort looking at Staten Island’s future (New York City 2011b). Literature from the task force indicates that small sections of the shore could become park or mixed-use areas, while others will remain waterfront-manufacturing locations. This change would have minimal impact on the current shoreline characterization of the NBSA as a whole. The North Shore of Staten Island consists of two areas of land, totaling 0.4 mile, which are described in the North Shore 2030 plan as "New waterfront open space public access," but are currently characterized as industrial/manufacturing – no access. Depending on the final outcome of the redevelopment, this 0.4 mile could become areas with recreational access to the NBSA. With the exception of a 0.4-mile stretch on the North Shore of Staten Island, none of the redevelopment plans indicate that future exposures to sediments and water will be different than current exposures.

3. References

City of Bayonne. 2000. *City of Bayonne Master Plan 2000.* Available online at: http://www.bayonnenj.org/masterplan

City of Bayonne. 2001. *City of Bayonne Zoning Map.* Prepared by Heyer, Gruel & Associates, PA.

City of Elizabeth. 2012. *City of Elizabeth Zoning Map.* Prepared by Harbor Consultants, Inc. February 21, 2000; revised 2012.

City of Kearny. 2009. Kearny Zoning. Available online at www.kearnyusa.com/sites/default/.../Kearny%20Zoning%202009.pdf

City of Newark. 2004. *Existing Land Use Map*. November. Available online at www.ci.newark.nj.us/

Construction Journal. 2012. *Redevelopment Plan for the Kapkowski Road Redevelopment Area, Project Report #810567.* February. Available online at: http://www.constructionjournal.com/project_print.aspx?id=810567

Jersey City. 2001. *Jersey City Zoning Map.* City of Jersey City Planning, adopted April 11.

Jersey City. 2008. *Bayfront I Redevelopment Plan.* February.

New York City. 2011a. *Zoning Map 20c.* New York City Planning Commission. May 5.

New York City. 2011b. *North Shore 2030.* Department of City Planning and the New York City Economic Development Corporation. December.

Schoor DePalma, Inc. 2005. *Master Plan. City of Elizabeth, Union County, New Jersey.* Prepared for City of Elizabeth Planning Board. October.

Appendix C

The Intelligence Group (TIG)
Reconnaissance Survey

Appendix C
The Intelligence Group
Reconnaissance Survey

Table C1 The Intelligence Group (TIG) Reconnaissance Field Notes

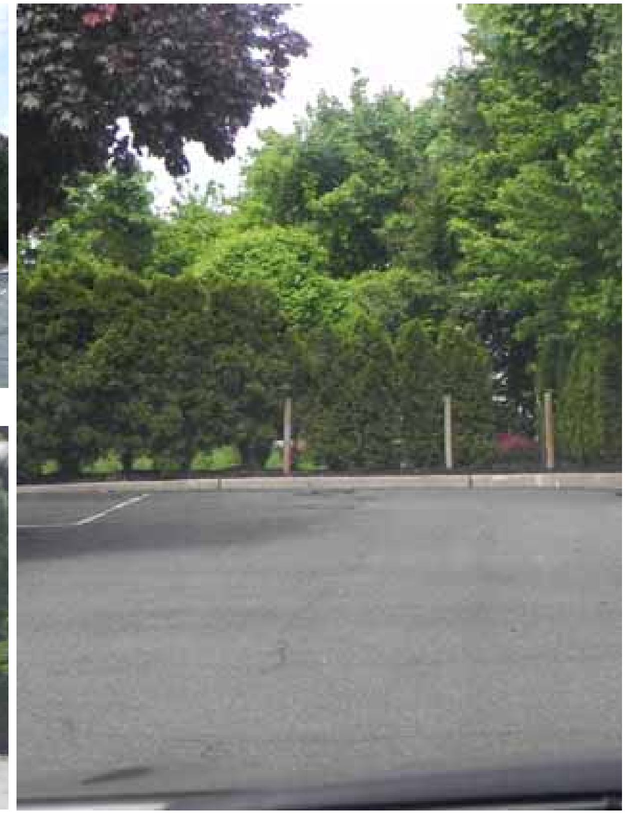
City	General Area	Specific Area	Reason Follow Up Requested	Notes During Reconnaissance	Final Characterization
Jersey City	Droyers Point	Open field area	Need to see if there is access to the sediment in the open field area	Easy access to water by walking across open field; water level appears to be 10 feet or less from ground	NI - Recreational Access
Bayonne	Park Dr	Southeast end of park, where Hackensack Riverwalk ends	Appears to have stairs, but it is unclear if this is the case or where potential stairs lead	Small shoreline area, appears to be inaccessible to public; terrain at end of W37th Street, Wesley Court, Benmore Terrace, etc. from street level down to water very steep, brush covered, rocky; would be very difficult & dangerous for public to navigate; no steps observed from street level down to water; barrier walls seen in backyards of some homes	NI - Recreational Access
Bayonne	W 37th St	End of Street	Determine if there is access from the house on the end of W 37th	Road dead ends; no observed pathways down to water; based on vantage point, terrain at end of W37th Street from street level down to water very steep, brush covered, rocky; would be very difficult & dangerous for public to navigate	NI - Recreational Access
Bayonne	Benmore Terrace	End of Street	Determine if there is access from the house on the end of Benmore Terrace	It does not appear as if there is access from the house down to the water; based on observations from Hackensack River Walkway, terrain from house to water would be an extremely steep drop down to water level	NI - No Access
Bayonne	Lincoln Parkway	End of Street	Determine if there is a fence at the end of the street, and if there is access to the bay off to the left	Locked fence with steep road down to what is believed to be Bayonne Sewage Pumping Station; fence continues along side of residence	NI - No Access
Bayonne	W 24th St	End of Street	Characterize access from the community of trailers	Mobile home park w/Bayfront parking lot for residents vehicles; certain vehicles appear to be filled to window-level with belongings and/or garbage; easy shoreline access to water via parking lot; certain mobile homes are waterfront but have fences	NI - Recreational Access
Bayonne	W 8th St	End of Street	Determine if there is access from the house on the end of W 8th St (see photo)	Road dead ends; no observed pathways down to water; terrain at end of W8th Street from street level down to water very steep, brush covered, rocky; would be very difficult & dangerous for public to navigate	NI - No Access

Note:
NI = non-industrial

Appendix C
The Intelligence Group
Reconnaissance Survey

Jersey City – Droyers Point

Bayonne – Park Drive



Bayonne W 37th Strreet

Appendix C
The Intelligence Group
Reconnaissance Survey

Bayonne – Benmore Terrace

Bayonne – Lincoln Parkway

Bayonne – West 24th

Bayonne West 8th

Appendix D

Land Use Research Log

Table D1 – Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Received Response?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
NJ State Police, Newark Bay Marine Services Bureau at Port Newark	973-578-8173	4/30/12	No	--	Commercial diving, recreational activities/boating, hunting	--
NJ State Police, Maritime Questions	lppmsb@gw.njsp.org & roic@gw.njsp.org	5/2/12	Yes	5/13/12	Commercial diving, recreational activities/boating, hunting, shooting	Contact NJSP Newark Bay Station personnel (973-578-8189).
Port Authority, NY/NJ	panynj.gov/feedback/ (submitted questions online)	3/30/12 & 4/30/12	Yes	5/18/2012 (from Kathy Kovach, kkovach@panynj.gov)	Commercial diving, recreational activities/boating	The Port Authority regularly inspects its underwater infrastructure. Diving work is subject to OSHA Commercial Diving requirements. Port Authority does not serve as a harbormaster; rather, the U.S Coast Guard is responsible for enforcement of waterway regulations & activities, as well as possibly municipal, county, & state agencies having similar jurisdiction. Information on recreational activity can be requested from local jurisdictions.
Port Authority, NY/NJ	212-435-3008	4/2/12	No	--	Commercial diving, recreational activities/boating	--
US Coast Guard (response from Jeff Yunker)	LNM@d1.uscg.mil	4/2/12 & 4/30/12	Yes	5/3/12	Commercial diving	Questions regarding bridge work in Newark Bay may be addressed to Joe Arca at 212-668-7069 or Joe.M.Arca@uscg.mil. OSHA diving regulations are published in Title 29 CFR Part 1910 Subpart T and are available at ecfr.gpoaccess.gov.
US Coast Guard (response from Jeff Yunker)	LNM@d1.uscg.mil	4/2/12 & 4/30/12	Yes	5/3/12	Recreational activities/boating	Recreational boating information is available at New Jersey State Boating Law Administration, Newark Bay, state.nj.us/njsp/maritime/msb-location.html or 973-578-8173. The Marine Trades Association of NJ publishes a Boater's Directory and Boat Ramp Guide. They are available online or to order at mtanj.org in the "Boater Information" section or 732-292-1051.
Randive	randive.com/contact-us.php; divingservices@randive.com	4/30/2012 & 5/1/12	Yes	5/1/12	Commercial diving	All commercial diving operations are covered by OSHA, USCG, and ADC International. We engage in every aspect of commercial diving, including general maintenance and repair work on either a scheduled or emergent basis.
Dryden Diving Company	drydiv@hotmail.com	5/1/12	Yes	5/1/12	Commercial diving	Our divers are subject to commercial diving regulations as established in the OSHA regulations. Many divers in the New York area work 200 or more days per year for 6 or more hours per day. There is no limit on the consecutive days worked for a diver.
John Christenson of Pile Test Inc; also listed for Coastal U/W Service M&J Marine	732-899-3034	4/30/12	Yes	4/30/12	Commercial diving	Company has commercial diving year-round; does work in Newark Bay. Time spent diving varies greatly with project; no limit on days in a row divers can work. Follow OSHA commercial diving regulations. Work 8 to 10 hour days. Perform contamination work, piles, ongoing work in Bay for Honeywell.
Leah Graziano, ATSDR, NYC	escobar.leah@epa.gov	4/30/12	No	--	Commercial diving, recreational activities/boating	--
NJDOT	maritime@dot.state.nj.us	5/2/12	No	--	Commercial diving, recreational activities/boating	--
Manhattan Kayak Company	info@manhattankayak.com	3/30/12	Yes	4/1/12	Recreational activities/boating	We do not offer kayak trips on Newark Bay, and we don't have any specific information re: outfitters offering services for that body of water.

Appendix D

Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Received Response?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
Passaic River Boat Club	passaicriverboatclub.info/PRBC/Joomla/index.php?option=com_contact&view=contact&id=2&Itemid=9 (online request)	5/2/12	No	--	Recreational activities/boating	--
Bill Sheehan, Hackensack Riverkeeper	info@hackensackriverkeeper.org	5/2/12	No	--	Recreational activities/boating	--
Essex County Dept of Parks, Rec & Cultural Affairs	joedi@admin.essexcountynj.org	4/2/12	No	--	Recreational activities/boating	--
Hudson County Div of Parks, Director	bruttler@hcnj.us	4/2/12	No	--	Recreational activities/boating	--
Union County Parks	nyc.gov/html/mail/html/maildpr.html (online request; response from parksinfo@ucnj.org)	4/2/12	Yes	4/2/12	Recreational activities/boating	Passed along contact info for City of Elizabeth's Recreation Department & Union County Police Marine Unit.
New York Commissioner, Dept of Parks & Recreation	nyc.gov/html/mail/html/maildpr.html (online request)	4/2/12	No	--	Recreational activities/boating	--
City of Elizabeth Parks & Recreation	908-820-4226	4/3/12	Yes	4/3/12	Recreational activities/boating	Ashley believes there are no Bay recreational exposures. She has lived in the area 20 years and has never seen anyone go into Bay water; hasn't observed any recreational activities on the Bay.
Union County Department of Emergency Management	908-654-9800	4/3/12	Yes	4/3/12	Recreational activities/boating	Kelly believes there are no recreational activities on Newark Bay; has never seen anyone boating, canoeing, etc. in the Bay.
Lynette Lurig, NJDEP	609-633-1314	4/30/12	Yes (response to later email)	4/30/12	Recreational activities/boating	Tied up until late week of 5/7/12; will be available to talk then.
Lynette Lurig, NJDEP	Lynette.Lurig@dep.state.nj.us	5/1/12	Yes	5/1/12	Recreational activities/boating	Tied up until late week of 5/7/12; will be available to talk then.
Lynette Lurig, NJDEP	609-633-1314	5/18/12	Yes	5/18/12	Recreational activities/boating	New park in Newark to open soon; Passaic now has more access points for fishing than did previously. Recreational activity on Bay has increased in the past 6 to 7 years. Most recreational water activity is on nearby waterbodies, but has also observed it in the Bay. Has observed sailboating; a livery is present on the Bay. Has seen canoes, kayaks, & boat ramps in Meadowlands, Woodbridge. Boats go through Arthur Kill to Bay; has observed people putting in kayaks in Elizabeth, above Secaucus behind Meadlowlands. New facilities and jet ski companies in the area; some in the Bay, some closer to the coast. Re: marinas/boat rental facilities on Bay - Robbins Reef Yacht Club in Bayonne; Hackensack Riverkeeper has livery which rents canoes/kayaks. Marinas in Arthur Kill, Perth Amboy. Has observed people bird watching. The Bay is somewhat dangerous for small boats, as large container ships are often present. Some condos/townhouses in Bayonne have moorings. Sailboats are docked in Newark Bay (may go out to ocean).
Debbie Mans (NY/NJ Baykeeper)	debbie@nynjbaykeeper.org	5/1/12	Yes	5/1/12	Recreational activities/boating	Passed along websites for Hackensack Riverkeeper, Passaic River Boat Club, & Passaic River Yacht Club.

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Tim Iannuzzi & Melissa Beauchemin, ARCADIS	Tim.Iannuzzi@arcadis-us.com, Melissa.Beauchemin@arcadis-us.com	4/30/12	Yes, from Melissa	4/30/12	Types of birds that may be hunted in/around Newark Bay, contacts for boating companies, contacts for harbor staff (e.g., for opening bridges)	Provided names of Miller's Launch Marina & Elco Boat Basin.
Luxergy (Jet Skiing)	luxergy.com	3/30/12	No	--	Some info found on website	Website says Luxergy no longer offers jet skiing in Bayonne, Elizabeth, Newark, or Passaic.
Luxergy (Jet Skiing)	888-589-3749	4/30/12	No	--	Asked why no longer offer jet skiing in the 4 cites listed above	--
Sven VanBatavia, Miller's Launch	sven@millerslaunch.com	4/30/12	No	--	Recreational activities/boating, contact information for Harbormaster	--
Chief Mark Chicketano, NJ Div of Fish & Wildlife, Bureau of Law Enforcement, Trenton	Mark.Chicketano@dep.state.nj.us	1/20/12 (Response forwarded by E. Naranjo)	Yes	1/20/12 (Response forwarded by E. Naranjo)	Is hunting legal in Newark Bay?	It is entirely legal to hunt in Newark Bay. All hunting regulations which are applicable elsewhere would of course apply. There is no generalized prohibition against it; it is inherently legal.
Chief Mark Chicketano, NJ Div of Fish & Wildlife, Bureau of Law Enforcement, Trenton	Mark.Chicketano@dep.state.nj.us	4/3/12	Yes	4/4/12	Likelihood of fowl and amphibian consumption by people in the vicinity of Newark Bay.	After 28 yrs in law enforcement, I have NEVER heard of anyone hunting waterfowl or collecting amphibians in Newark Bay. There is, however, a fairly large group of hunters who hunt waterfowl in the Hackensack River, mostly on the Sawmill Creek Wildlife Management Area located in Lyndhurst, Carlstadt, and Secaucus, and a very limited number of waterfowl hunters in the lower Passaic River. I've not heard of anyone in this area (the Hackensack or Passaic Rivers) collecting amphibians.
Reyhan Mehran & Jay Field, NOAA	reyhan.mehran@noaa.gov, jay.field@noaa.gov	4/10/12	Yes (From R. Mehran)	4/12/12	Commercial diving	In addition to the USCG and the PA, reach out to ATSTDR in NYC (Leah Graziano). For commercial divers, try contacting Dryden Diver Co, K B Commercial Diving, North Atlantic Commercial Diving, and M&J Marine & see if they have any work going on now or know of anything planned. Also see if Marian Olsen at EPA, Anne Hayton at NJDEP, or Tim Kubiak at USFWS have other suggestions (if you haven't checked with them already; I have copied them on this email).
Reyhan Mehran & Jay Field, NOAA	reyhan.mehran@noaa.gov, jay.field@noaa.gov	4/10/12	Yes (From R. Mehran)	4/12/12	Recreational activities/boating	For recreational activities, contact the NY/NJ Baykeeper (Debbie Mans) & the various boat clubs.
Anne Hayton, NJDEP	Anne.Hayton@dep.state.nj.us	4/12/12	Yes (Reyhan forwarded Anne my original email)	4/12/12	Commercial diving	For commercial divers or construction workers, seek info from both private & government agencies which fund marine-related maintenance work, e.g., Port Authority of NY/NJ, dredging companies, USACE (Bryce Wisemiller), NJDOT, & NJ State Police. Eugenia Naranjo (USEPA) may be able to provide contact names/numbers, email addresses for other Bay Agency Coordination participants.
Anne Hayton, NJDEP	Anne.Hayton@dep.state.nj.us	4/12/12	Yes (Reyhan forwarded Anne my original email)	4/12/12	Recreational activities/boating	For recreational activities, please contact Lynette Lurig, NJDEP & the NJ State Police.
Bryce Wisemiller, USACE	bryce.w.wisemiller@usace.army.mil	4/10/12	Yes	4/10/12	Commercial diving	Would be difficult to estimate any time spent by divers related to our HDP construction. The Corps generally does not allow for any diving in our contracts unless an expected occurrence in a contract happens. Contact one of the commercial diving companies that work for the various dredging or marine construction companies (e.g., Randive) to obtain actual exposure information.

Appendix D

Land Use Research Log

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Bryce Wisemiller, USACE	bryce.w.wisemiller@usace.army.mil	4/10/12	Yes	4/10/12	Recreational activities/boating	The only information I would have on recreational usage in the Newark Bay would be anecdotal based on my own personal experience in the Bay. The most prevalent recreational usage of the Newark Bay I'm aware of, by far, is recreational fishing, particularly at publically accessible locations such as the Elizabeth Marina. While I would hope that these fishermen do not consume the fish they catch (as the signs everywhere advocate), I know from speaking to several of them over the years that many do indeed consume the fish that are caught from the Bay.
US Coast Guard	Joe.M.Arca@uscg.mil	5/7/12	Yes	5/8/12	Commercial diving, construction	We do not keep a list of divers that work in our area. However, David J. Sheridan, Sr. does a lot of work in the area and can probably assist (908-685-0456, southtrader@mindspring.com).
Marine Trades Association of New Jersey	info@mtanj.org	5/7/12	Yes	5/7/12	Recreational activities/boating	Forwarded inquiry to staff at NJDOT, Coast Guard & Ray Fusco (consultant). Ray Fusco said he could provide information.
Ray Fusco	m: 410-299-1917, o: 845-509-5999	5/7/12	Yes	5/7/12	Recreational activities/boating	Mr. Fusco has projects on Port of NY/NJ; has NJDOT Harbor Safety Grant. Some recreational boating on Bay. Since is an industrial area with shipping traffic, it seems boating in Bay is mainly to get to other recreational areas (e.g., Hackensack, Passaic, Arthur Kill, Kill van Kull). Fishing is common. Robbins Reef Marina (in Bayonne) is only marina he's seen on the Bay. Recommended search list of NJ marine boat launches to see proximity; perhaps boat launch in Laurel Hill or Lincoln Park. He doesn't know of any canoe/kayak rentals in the Bay.
7 boating companies/marinas listed on the Marine Trades Association of New Jersey's website	debbie@grassysoundmarina.com, deeluvmm@aol.com, marina@irwinmarinenj.com, lakeviewdocks@comcast.net, info@pier47.com, SShoreMrna@aol.com, emccann@vikingyachts.com	5/7/12	Yes; from Irwin Marine	5/7/12	Recreational activities/boating	Recommended contacting the Marine Trades Office directly.
List of New Jersey Marinas	jerseymarinas.com/ramp.htm	6/6/12	Located marina list on website	6/6/12	Located marina list on website	One boat ramp listed in Newark Bay: Bayonne Municipal Launching Ramp, West Shore Drive & West 16th Street, Bayonne, NJ, 201-858-612.